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AN INVESTIGATION OF AN EXPERIMENTAL CALIBER .22 HIGH-VELOCITY BULLET FOR RIFLES (UNCLASSIFIED)

THIRTY-FIFTH REPORT ON PROJECT NO. TR1-2

DEVELOPMENT AND PROOF SERVICES
ABERDEEN PROVING GROUND
MARYLAND

AUTHORITY: ORDTS
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THIRTY-FIFTH REPORT ON PROJECT NO. TS1-2

DATES OF TEST: 8 NOVEMBER 1954 TO 22 SEPTEMBER 1955

OBJECT

To investigate some interior-, exterior-, and terminal-ballistic properties of ammunition employing an experimental caliber .22 rifle bullet designed by Development and Proof Services at Aberdeen Proving Ground.

SUMMARY

A contract was negotiated for fabrication of 5000 experimental caliber .22 high-velocity rifle bullets in accordance with a design proposed in Development and Proof Services Thirtieth Report on Project No. TS1-2. The bullets procured were loaded in re-formed caliber .30 Light-Rifle (7.62 mm NATO) cartridge cases with suitable components, to give a muzzle velocity of approximately 3400 fps, in accordance with previous proposals in the Report cited above. This ammunition was fired in test weapons for determination of velocity, accuracy, stability, ballistic coefficient, and penetration in certain targets. By arrangement with the Medical Division, Biophysics Branch, of the Army Chemical Center, a wound-ballistic evaluation of the experimental ammunition was made by that agency, and results of that evaluation comprise Appendix C of the present Report. For purposes of convenient comparison, some data have been included for standard types of caliber .30 ammunition - principally the lead-core M2 ball, which is the standard round most nearly comparable to the experimental ammunition tested.

CONCLUSIONS

The ammunition employing the experimental caliber .22 HV rifle bullet was superior to caliber .30 M2 ball with respect to impact velocities, flatness of trajectory, deflection by cross-wind, perforation of armor plate, perforation of helmets, penetration of pine boards at 2000 yards, lightness of recoil, and lightness of weight. With respect to over-all wound-ballistic performance, it was approximately equal to caliber .30 bullets with which it was compared. The accuracy of the test bullets was excellent when IMR propellant was used, and very good when XL487.2 ball propellant was used if chrome-plated bores were employed, but the XL487.2 ball propellant available gave objectionable fouling even in

chrome-plated bores and intolerable fouling in bores which were not chrome-plated.

RECOMMENDATIONS

It is recommended that using forces be invited to comment on results of the testing described here.

Contingent upon the using forces' expression of further interest, it is recommended that additional weapons and ammunition be procured for further engineering development, and for such evaluation as using forces may desire to make at that time.

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I INTRODUCTION

A. DISCUSSION

1. As a result partly of theoretical considerations, and partly of experiences and observations of engineers at this station with high-velocity non-military weapons, it was felt that some advantages might accrue from investigation of high-velocity cartridges in military shoulder arms. In April 1952, verbal authority was granted by the Director of Development and Proof Services and the Chief of the Arms and Ammunition Division at this station to proceed in this endeavor in such manner as not to interfere with the course of assigned development testing under direction of the Office of the Chief of Ordnance. Attention was first devoted to development of a small high-velocity cartridge, adaptable to a weapon such as the M2 carbine; present status of that effort is described in the Twenty-Fifth and Thirty-Third Reports on Project No. TS1-2. Concurrently, however, investigation was progressing on a high-velocity cartridge of higher energy level, having dimensions suitable for use in rifle mechanisms. Meanwhile, at the direction of the Office of the Chief of Ordnance, on 2 June 1953, the work on high-velocity small-caliber cartridges in Development and Proof Services at this station was removed from a not-to-interfere status and continued at an accelerated pace as an assigned project. The initial report on a high-velocity small-caliber round for employment in rifles is the Thirtieth Report on Project No. TS1-2, published 22 April 1954; the present report describes a continuation of that development effort.

2. In the previous report (Development and Proof Services Thirtieth Report on Project No. TS1-2) some considerations of theoretical advantages of a small-caliber, high-velocity cartridge for shoulder weapons were discussed. As a means of investigating some of these considerations, ammunition was prepared using modified components of certain commercial and military ammunition. Some test weapons and an automatic rifle were fabricated or adapted to fire the experimental ammunition, and some preliminary testing was conducted. The results of this testing indicated, first, that the experiment was sufficiently promising to justify further pursuit, and, secondly, that the next logical step was the design of a small-caliber bullet having acceptable military characteristics for rifle use. Such a bullet was designed, its ballistic properties were estimated, and the characteristics of a cartridge employing the proposed bullet were described in an appendix to the aforementioned report. Procurement, for testing purposes, of ammunition of the proposed type was recommended.

3. Subsequent to publication of the Thirtieth Report on Project No. TS1-2, authority was granted to proceed with procurement of bullets of the proposed design. This was accomplished by contract with the Sierra Manufacturing Company, of Whittier, California. The original quantity procured for these tests was 5000, but prior to publication of the present report, additional quantities (approximately 100,000) were ordered by other agencies, on the basis of early results of the tests described here, for their own experiments. The present report deals with some performance characteristics of the ammunition assembled with the bullets of the original lot of 5000.

4. The following quotation has been extracted from DISCUSSION of the Thirtieth Report on Project No. TS1-2: "Some evident advantages of the small-caliber high-velocity cartridge are reduction in recoil, some saving in weight, greater flatness of trajectory over effective rifle ranges, and improved muzzle-compensator efficiency owing to the high ratio of charge weight to bullet weight. Some foreseeable disadvantages include difficulty in producing special-purpose bullets such as tracer and incendiary, increased erosion as a consequence of higher velocity, and some reduction in impact energies and penetration in certain media. These disadvantages seem to be most important, however, in a machine gun round, and much less important in rifle ammunition. It was considered likely that a net advantage of the small-caliber high-velocity round would be largely contingent upon acceptability of the premise that rifle and machine gun ammunition need not be interchangeable." A quantitative evaluation of some of the characteristics cited above were investigated in the tests described in the earlier report. The present report is primarily intended to present data on those characteristics which have been changed by employment of the newly designed bullet. For convenient references, however, some data on other characteristics have been extracted from the earlier report, and are presented here again.

B. REFERENCES

1. Authority for this test is contained in teletype OKD 1548 dated 7 January 1955, a copy of which comprises Appendix A of this report.

2. Technical References include the following:

a. Twenty-fifth Report on Project No. TS1-2.

b. Twenty-eighth Report on Project No. TS1-2.

c. Thirtieth Report on Project No. TS1-2.

d. Thirty-third Report on Project No. TS1-2.

e. Firing Record No. S-16201 (Appendix B).

f. Medical Laboratories Research Report No. 291, "Wound Ballistics Assessment of the .30 Caliber T21 Ball, the .30 Caliber Armor Piercing M2 Bullet, and the .280 Caliber United Kingdom Lead Core Ball", dated June 1954.

g. Medical Laboratories Research Report No. , "Wound Ballistics Assessment of an Experimental .22 Caliber Lead-core High-Velocity Rifle Ball: Comparison with 7.62 mm NATO (.30 Caliber T21) Rifle Ball", dated (Appendix C).

II DESCRIPTION OF MATERIEL

A. The experimental bullet designed for these tests is of conventional lead-core ball construction, has a gilding-metal jacket, a seven-caliber tangent ogive, and a nine-degree boattail of approximately .8-caliber length. It is

essentially a .224-caliber homologue of the obsolete caliber .30 M1 ball. A drawing of the bullet, together with some further description and estimated ballistic properties, appeared in Appendix F of the Thirtieth Report on Project TS1-2. The dimensions of the test bullet conform to those of the design drawing (Appendix D) except that the actual weight is slightly greater (about two grains) than the calculated value of "approximately 66 grains". The aerodynamic properties closely approximate those estimated at the time the bullet was designed.

B. The cartridge case for the experimental ammunition was the modified and re-formed caliber .30 FA T1E3 case described in the Thirtieth Report on Project No. TS1-2, a sketch of which is included in Appendix D of the present report.

C. The propellant employed for "service" loads of the experimental ammunition is of Western-ball type, designated X 487.2, intended originally for high-velocity 30mm aircraft-gun cartridges such as the T206E10. It is not completely suitable for the experimental caliber .22 ammunition, producing fouling in the bore, which accumulates very rapidly unless chrome-plated barrels are employed. It does meet (and slightly exceed) the anticipated velocity level upon which ballistics for the proposed cartridge were estimated, however, and was the most nearly suitable propellant available at the time of these tests. As indicated in the Round-by-Round data, some firing was done with IMR 4350, with no evidence of troublesome fouling, but neither the effective burning rate nor gravimetric density of this, or other IMR-type propellants, were suitable for attaining maximum capabilities of the experimental cartridge; a ball-propellant load was therefore selected for the "service" charge.

D. The weight of a complete round of the experimental caliber .22 cartridge is approximately 280 grains, as compared to about 396 grains for a round of caliber .30 M2 ball.

E. The proof weapons employed for the experimental cartridge were, except for necessary differences associated with caliber, similar to standard caliber .30 accuracy rifles (D7692088) and pressure gages (D286934). Barrel length in each weapon was 22 inches. Groove and bore diameters were approximately .224 inches and .219 inches respectively, and barrels had six lands with a uniform right-hand twist of one turn in ten inches, or one turn in eight inches, as noted in the firing data. One barrel with ten-inch lead of rifling was chrome-plated by the Marker Machine Company of Charleston, Illinois; the other barrels were unplated. All barrels were obtained from rifled blanks produced by the Apex Rifle Company, Sun Valley, California.

III DETAILS OF TEST

A. PROCEDURE

1. Fabrication of proof weapons was accomplished in the experimental gunsmithing shop of the Infantry and Aircraft Weapons Division at this station. Insofar as possible, tooling described in the Thirtieth Report on Project No. TS1-2 was utilized. The only important new facilities required were weapons having 8-inch and 10-inch leads of rifling for the newly designed bullet, instead

of the 14-inch lead of the weapons used in the earlier tests. It was anticipated that tests with 8-inch and 10-inch twists would yield data upon which a firm choice of rifling lead for the new bullet could be made; it had previously been estimated (cf. Thirtieth Report on Project No. TS1-2) that a nine-inch lead, would be approximately correct.

2. To establish a suitable charge with the new bullet, firing was conducted in a locally fabricated caliber .22 HV pressure gage. Procedures were generally in accordance with those prescribed for small-arms pressure tests in ORD-M608-PM, Volume III, of the Ordnance Proof Manual. The intent was to obtain the highest possible velocity within a "copper" chamber pressure of 52000 psi. All loading was done on a Pacific-type reloading press, using locally fabricated dies for case-forming, resizing, and reloading operations. Charges for charge-establishment were weighed on a modified analytical balance, and thereafter were thrown from a volumetric measure.

3. To establish the velocity level of the ammunition assembled, velocity series were fired in accordance with prescribed Proof-Manual procedures, employing locally fabricated accuracy rifles (Mann barrels), as noted in Round-by-Round Data.

4. Accuracy testing was conducted at 100 yards and at 600 yards, in the manner prescribed by ORD-M608-PM, Volume III. Initial attempts with ball propellant were unsuccessful, however, as group sizes increased systematically and rapidly, after cleaning the barrel, as a consequence of accumulating fouling. Efforts were made to obtain another ball propellant with suitable ballistic properties and less tendency to produce fouling, but these efforts were unsuccessful inasmuch as no existing propellant was satisfactory, and the limited quantity of ammunition involved did not justify procurement of a special lot. An accuracy rifle (Mann barrel) was then chrome-plated in an effort to alleviate the fouling problem, and this barrel was fired for nineteen consecutive ten-shot groups at 600 yards, without cleaning, to observe the accumulation of fouling and the effect on accuracy. For comparison, the chrome-plated barrel was thoroughly cleaned after having fired approximately 200 ball-propellant loads, and sixty loads using IMR 4350 propellant were fired, the last fifty of these being used to make five ten-shot groups at 600 yards.

5. To establish drag characteristics of the experimental bullet, firing was conducted at ranges of 200, 600, 1000, and 2000 yards for measurement of remaining velocities. From these data, standard-condition impact velocities, remaining energies, cross-wind deflections, maximum ordinates, and elevations for the experimental ammunition were calculated by methods described in the Twenty-eighth Report on Project No. TS1-2 and the usual Siacci methods applicable to flat trajectories.

6. To obtain some information on terminal-ballistic properties of the experimental ammunition, penetration tests were fired against helmets and against 1/4-inch homogeneous armor plate at various ranges as noted in Round-by-Round Data. Caliber .30 Ball M2 ammunition was used for control where comparable data for the caliber .30 round were not otherwise available. Data were also obtained on a pine-board target at 2000 yards, in conjunction with exterior-ballistic tests at this range.

7. To determine the maximum lead of rifling which would produce adequate stability for the experimental bullet under anticipated field conditions, yaw-card firing was conducted from barrels with 8-inch and 10-inch leads. These data were reduced to yield standard stability factors, from which data, recommendations could be made as to a desirable lead of rifling for future weapons employing the newly designed bullet. More complete procedures for these tests are contained in Firing Record No. S-46201, which comprises part of Appendix B of this report.

8. Inasmuch as recoil-pendulum data were taken for the Thirtieth Report on Project No. TS1-2 using a 63-grain bullet and 42.6-grain charge, these tests were not repeated for the new experimental ammunition. Since the new ammunition employs a 68-grain bullet and 51-grain charge, the effect of these changes was considered sufficiently small to be calculated from the previous data with acceptable accuracy. This calculation was based upon measured quantities for the new ammunition, except for effective exit velocity of the propellant gases, which was assumed to be the same as that measured in the earlier tests with the 63-grain bullet. Data for the caliber .30 M2 ball cartridge are presented for comparison.

9. By arrangement with the Biophysics Division, Chemical Corps Medical Laboratories, Army Chemical Center, Maryland, wound-ballistic studies of the experimental ammunition were made. Procedures for these studies are given in MLRR No. , which comprises Appendix C of this report.

B. RESULTS

1. As a result of charge-establishment firing reported in Appendix B, a charge of 51.0 grains of X 4872 was selected for "service" loading. A twenty-round velocity series was fired with this charge in an accuracy rifle with ten-inch lead of rifling, and a twenty round pressure series was fired in a gage with eight-inch lead. Only uncorrected data could be obtained, of course, since calibration components for the experimental ammunition are not available. A tabulated summary follows:

Velocity Series:

Average IV, fps at 78 ft.	:	3362
Corresponding MV, fps	:	3428
Extreme Variation, fps	:	117
Standard Deviation, fps	:	32

Pressure Series:

Average Chamber Pressure, psi (Cu)	:	51985
Extreme Variation, psi	:	3400
Standard Deviation, Psi	:	1010
Average S.P. Velocity, fps at 78 ft	:	3375

2. The results of Mann-barrel accuracy testing are summarized below:

a. Initial tests fired at 100 yards with a charge of 42.0 grains of IMR 4350 gave the following average results, based on four ten-shot targets, in an indoor range:

Extreme Vertical Dispersion, Inches :	1.20
Extreme Horizontal Dispersion, Inches:	1.33
Extreme Spread, Inches :	1.54

b. Two ten-shot groups at 100 yards from an accuracy rifle were taken simultaneously with the 20-shot velocity series, using 51.0 grains of X 487.2 propellant, and giving the following average group dimensions:

Extreme Vertical Dispersion, Inches :	1.15
Extreme Horizontal Dispersion, Inches:	1.39
Extreme Spread, Inches :	1.55

c. In an accuracy test at 600 yards, using an unplated accuracy rifle (Mann barrel) and a 51-grain charge of X 487.2 ball propellant, groups increased from 3.2-inch mean radius to 12.6-inch mean radius in the firing of forty rounds. Inspection of the bore revealed a heavy accumulation of fouling. Upon removal of the accumulated fouling from the bore, three ten-shot groups were fired. The first two groups gave mean radii of 2.7 and 4.6 inches, respectively, and one round of the last group missed the 6x6-foot target, whereupon firing was suspended because of rapid re-accumulation of fouling. Individual group measurements are given in Appendix B.

d. Using a barrel with a chrome-plated bore, 19 ten-shot groups, fired without cleaning, yielded an average mean radius of 4.56 inches at 600 yards, using the ball-propellant load described in paragraph 2 C. above. There was some evidence that dispersion increased during the first forty or fifty rounds after cleaning the bore, and inspection of the bore after 50 rounds showed some accumulation of fouling. The dispersion did not appear to increase further after about fifty rounds, and inspection of the bore after about 200 rounds did not indicate appreciably more fouling than was observed at 50 rounds. Dimensions of individual groups are given in Appendix B. A summary of group dimensions, in inches, for the 19 ten-shot targets at 600 yards is as follows:

	MR	MVD	MHD	EVD	EHD	ES
Group of smallest MR	3.0	2.9	2.3	9.5	9.7	10.4
Group of largest MR	6.6	5.1	3.3	17.4	13.5	17.5
Average of all groups	4.56	3.10	2.65	12.31	11.77	14.98

e. After thorough cleaning of the chrome-plated barrel referred to in paragraph 2 c., above, five ten-shot groups fired with a 42-grain charge of IMR 4350 propellant yielded an average mean radius of 3.1 inches at 600 yards. Inspection of the bore indicated no appreciable accumulation of fouling. Individual target measurements are given in Appendix B, and a summary of the five ten-shot groups follows:

	MR	MVD	MHD	EVD	EHD	ES
Group of smallest MR	2.2	1.9	1.0	7.0	4.7	8.5
Group of largest MR	3.7	3.0	1.7	10.4	7.6	11.2
Average of all groups	3.1	2.4	1.6	8.9	6.7	10.0

f. For purposes of comparison, the following data were extracted from the Third Report on Project No. TS1-2, and represent average dimensions of fifteen ten-shot groups (five groups from each of three barrels) at 600 yards, with caliber .30 M2 ball ammunition, lot number FA 4059. The applicable specification requires an average mean radius not greater than 7.5 inches; lot number FA 4059 is of approximately average quality.

	MR	MVD	MHD	EVD	EHD	ES
Average of 15 groups	5.44	3.32	3.68	12.79	14.44	17.48

3. Detailed results of remaining-velocity measurements are contained in Appendix B. These data, upon being reduced, yield the following trajectory characteristics applicable to standard, surface, atmospheric conditions. A muzzle velocity of 3400 fps has been used instead of the value of about 3430 fps which was attained with the 30mm propellant; the 3400 fps is regarded as a conservative estimate of velocity attainable in production loading. Values for caliber .30 ball M2 ammunition have been included for comparison in the following table:

RANGE	VELOCITY, fps.		ENERGY, ft-lbs		MAX. ORDINATE, ft.		ELEVATION, mils	
Yards	Cal..22	Cal..30	Cal..22	Cal..30	Cal..22	Cal..30	Cal..22	Cal..30
0	3400	2796	1755	2653	0	0	0.0	0.0
100	3149	2580	1506	2258	.09	.05	0.4	0.6
200	2905	2364	1281	1896	.15	.22	0.9	1.4
300	2670	2153	1082	1573	.36	.54	1.5	2.2
400	2441	1949	905	1289	.70	1.1	2.1	3.2
500	2220	1753	748	1043	1.2	1.8	2.8	4.3
600	2007	1568	612	834	1.9	3.0	3.6	5.5
700	1804	1396	493	661	2.9	4.5	4.6	7.0
800	1616	1239	396	521	4.2	6.7	5.7	8.8
900	1446	1110	317	418	6.0	9.6	6.9	10.6
1000	1296	1031	255	361	8.4	13.5	8.3	13.3
1500	935	731	133	181	---	---	---	---
2000	776	496	91	83	---	---	---	---

DEFLECTION EFFECT OF 10-MPH CROSSWIND IN FEET AT TARGET

RANGE Yards	Caliber .22	Caliber .30	RANGE Yards	Caliber .22	Caliber .30
100	.06	.06	500	1.5	2.0
200	.22	.27	600	2.3	3.1
300	.48	.64	800	4.6	6.3
400	.92	1.22	1000	8.1	11.0

4. The results of nine fair hits on a target of three courses of one-inch pine boards spaced at one-inch intervals at 2000-yard range gave complete perforation of three boards (the entire target thickness) on eight rounds and penetration of 2 3/4 boards on one round.

5. Results of penetration tests against 1/4-inch homogeneous armor plate (BHN 364) and M1 helmets are summarized below for the experimental caliber .22 cartridge, with caliber .30 M2 ball for comparison:

TARGET TYPE	RANGE Yds.	Caliber AMMO.	FAIR HITS	*PARTIAL PENETRATIONS	*COMPLETE PENETRATIONS	*COMPLETE PERFORATIONS
Plate	100	.30	5	0	0	5
Plate	150	.30	5	5	0	0
Plate	300	.22	5	0	0	5
Plate	350	.22	5	1	0	4
Plate	400	.22	5	2	0	3
Plate	450	.22	5	5	0	0
Helmet	900	.30	6	3	2	1
Helmet	1000	.30	5	3	2	0
Helmet	1000	.22	5	0	0	5
Helmet	1100	.22	5	4	0	1

* Approximately as defined in OCD M508 PM, Vol. III, CPM 7-17:
Complete perforation - Bullet passes through plate or at least one side of helmet.
Complete penetration - Bullet opens crack through but does not pass through
Partial penetration - Any fair hit which is not within definitions above.

6. The standard stability factors of the experimental bullet, determined from yaw-card firing with barrels of 8-inch and 10-inch twists at "service" muzzle velocity of about 3,400 fps, are summarized below:

TWIST (inches/turn)	AMBIENT TEMPERATURE	REL. ATM. DENSITY	STABILITY FACTOR
10	Standard	1.00	1.16
9	Standard	1.00	1.42
8	Standard	1.00	1.81
10	-65°F.	1.38	0.84
9	-65°F.	1.38	1.03
8	-65°F.	1.38	1.31

7. Recoil characteristics of the experimental ammunition, obtained by computation from results reported in the Thirtieth Report on Project No. TS1-2, and allowing for changes in bullet and charge weights, are as given below, with data for caliber .30 M2 ball included for comparison.

CHARACTERISTICS	W/COMPENSATOR		W/O COMPENSATOR	
	Cal..22	Cal..30	Cal..22	Cal..30
Recoil Momentum, lb-sec	1.56	2.16	2.23	2.68
Recoil energy, ft-lbs, 7-lb rifle	5.6	10.7	11.3	16.4
Recoil energy, ft-lbs, 8-lb rifle	4.9	9.3	9.9	14.4
Recoil energy, ft-lbs, 9-lb rifle	4.4	8.3	8.8	12.8

8. The following results are based upon analysis of wound-ballistic data by the Chemical Corps Medical Laboratories, as reported in MLRR No. which comprises Appendix C of this record. The entry opposite "Max. Cavity Volume" is the approximate average temporary maximum cavity volume produced by penetration of the bullet into a tissue model, which consists of a cylinder of 20% gelatin, 12 cm long and 12.4 cm in diameter, the path of the bullet being approximately axial within the block. Round-by-round observations on maximum cavity volume are given in Appendix C, which appendix also contains results of firing against experimental animals at ranges up to about 1000 yards, and contains many other data of significance in a wound-ballistic comparison, but these other data cannot conveniently be summarized for presentation here. The maximum temporary cavity volume is probably the most significant single numerical criterion of wounding power, and is presented here at the risk of quoting out of context from the Medical Laboratories Research Report, but for complete experimental data, attention is here invited to Appendix C, where the wound-ballistic results appear in their entirety. Data for caliber .30 M2 ball were not available, but in the tabular summary below, data are presented for the caliber .30 AP M2 bullet (for which data are available in the reference cited in paragraph IB 2 f.) for comparison:

RANGE		Cal. .22 HV	Cal. .30 AP M2
10 Yards	(Real)	* 325 to 2110	334
440 Yards	(Real)	* 182 to 380	242
500 Yards	(Simulated)	118	140
600 Yards	(Simulated)	47	55

* Because some bullets tumble and some do not, data are widely scattered, and average values are not significant; figures are therefore given only to indicate the range of values.

C. OBSERVATIONS

1. Some theoretical advantages of small-caliber high-velocity bullets were discussed at length in a previous report on this subject (the Thirtieth Report on Project No. TS1-2), and those discussions will not be completely reiterated here. Briefly, the advantages include improved burst-fire accuracy (especially with muzzle compensators), greater flatness of trajectory, reduction in recoil, increased impact velocities, and some saving in weight. Disadvantages include limitations in performance of special-purpose bullets such as tracer and incendiary, and lack of interchangeability with machine-gun ammunition. The question has often arisen as to whether some measure of lethality would be sacrificed by reduction in caliber, and present information seems to indicate that it would not. The requirement for special-purpose bullets in rifle ammunition, and the degree to which this should be compromised for other considerations, can be established only on tactical precepts which are not within the scope of this report. The need for interchangeability of rifle and machine-gun ammunition can be affirmed or contradicted only upon tactical and logistical grounds, but present packaging practice seems to imply that interchangeability in the field is not essential. Ammunition intended for rifle use is packed in the eight-round en bloc clips which are necessary for normal operation of the M1 rifle, and machine-gun ammunition is packed in metallic link belts which are necessary for machine-gun functioning. Although single shots can be loaded and fired, somewhat laboriously, without clips for the M1 rifle or belts for a machine gun, for practical purposes, the ammunition packaged for one weapon is virtually useless in the field for the other. The situation would not seem to be greatly altered if rifle and machine-gun ammunition were supplied in their own respective calibers.

2. While the lead-core experimental caliber .22 bullet is superior in armor-penetration to lead-core caliber .30 M2 ball, it would not be comparable in this respect to caliber .30 M2 AP. No effort has been made to develop armor-piercing bullets in the experimental caliber .22 cartridge. There are certain advantages associated with lead-core bullets (cf. Thirtieth Report on TS1-2) which indicate their superiority for a general-purpose rifle round, and it was felt that rifle fire is relatively so ineffective against armor in any event, that development of a round specifically for defeat of armor was unjustified. This view, however, involves tactical considerations which are probably beyond the proper scope of this report. If the using forces express the view that armor-piercing bullets for rifle ammunition are essential, it seems reasonably

probable that a caliber .22 AP bullet could be developed to give performance comparable to that of current caliber .30 AP bullets.

IV CONCLUSIONS

A. The following conclusions are drawn with respect to comparison between specific performance characteristics of the experimental caliber .22 HV rifle ammunition and those of caliber .30 M2 ball:

1. The caliber .22 affords higher impact velocities at all ranges, the difference being approximately 20% at the muzzle, 25% at 1000 yards, and 61% at 2000 yards.

2. The caliber .22 affords flatter trajectories over all ranges, the difference in maximum ordinates being about 30% to 40% at ranges up to 1000 yards.

3. The caliber .22 requires less sight adjustment for elevation over all ranges, the difference being about 30% to 40% at ranges up to 1000 yards.

4. The caliber .22 is less deflected by cross-wind, the difference being approximately 25% at ranges from 300 to 1000 yards.

5. The caliber .22 has lower impact energies at all except very long ranges (nearly 2000 yards), but the terminal-ballistic properties - penetration and lethality - with which impact energy is sometimes associated, were not inferior for the caliber .22, as noted below:

a. The lead-core caliber .22 bullet will perforate light armor plate (1/4-inch, BHN 364) at greater range than will caliber .30 M2 ball, the range at which approximately half of the fair hits perforate being between 100 and 150 yards for the caliber .30, and at about 400 yards for the caliber .22.

b. The caliber .22 will perforate M1 helmets at greater range than will caliber .30 M2 ball, the range for mixed results (complete perforations and partial penetrations) being about 900 yards for the caliber .30, and about 1100 yards for the caliber .22.

c. With respect to lethality, there is some evidence that the experimental caliber .22 bullet is slightly superior to most caliber .30 bullets at ranges up to about 300 yards, that caliber .30 bullets may be moderately superior between 300 and 1000 yards, and that there is no important difference between the two from about 1000 to 2000 yards. The over-all performance of the two calibers is therefore probably not importantly different in this respect.

6. The caliber .22 cartridge produces less recoil than does the caliber .30, the free-recoil energies being about 50% less if compensators were used with both calibers, and about 30% less if no compensators were used with either caliber.

7. The weight of a complete round of the caliber .22 ammunition is approximately 30% less than that of a round of caliber .30 M2 ball.

8. The caliber .22 bullets employed in this test gave rather better accuracy than is usually obtained with caliber .30 production ammunition, but this difference may be attributable more to the quality of the individual bullet lot than to differences inherent in the design or caliber.

B. The ball-type propellant available for these tests is not completely suitable for the experimental caliber .22 cartridge, producing an undesirable accumulation of fouling in the bore, which fouling tends to increase dispersion. However, if chrome-plated barrels are employed, the accuracy is still very good, affording average mean radii of about 4.6 inches at 600 yards with the ball propellant, which is well within the 7.5-inch requirement for caliber .30 M2 ball. However (from the 3.1-inch mean radius obtained using IMR propellant) it is concluded that accuracy is still adversely affected by the ball-propellant fouling, even when chrome-plated bores are employed, and that ball propellant of more suitable type should be developed.

C. With respect to erosion characteristics of the experimental ammunition, no conclusion is presently possible, since no sufficient sample of ammunition, no suitable weapons, and no completely satisfactory propellants were available for erosion testing. It is concluded, however, that this important characteristic should be further investigated.

V RECOMMENDATIONS

A. It is recommended that comments be invited from the using forces on the contents of this report, and that the course of further development in the field of small-caliber high-velocity shoulder weapons take cognisance of the comments elicited.

B. Contingent upon the expression of further interest by the using forces, and subject to consideration of the using forces' views, the following immediate course of development is recommended:

1. Shoulder weapons of suitable type be equipped with chrome-plated barrels having nine-inch lead of rifling, and adapted to fire ammunition of the type employed in these tests.

2. Efforts be made to obtain propellant which is free from the objectionable fouling characteristics of the X 487.2 ball propellant used in these tests, but which retains the desirable interior-ballistic properties of the X 487.2. In this regard, it is further recommended that anti-fouling agents be incorporated only after very careful consideration of other approaches to the problem, since recent tests in other calibers have shown that such agents may detract from the desirable erosion performance which is characteristic of ball propellant.

3. A quantity of the experimental ammunition be procured, incorporating the desirable characteristics indicated by these tests, for further development testing, and for evaluation by using forces.

4. Quantities of weapons and ammunition procured be sufficient to provide for such tests as using forces may desire for their evaluation of the experimental cartridge, and at least four weapons and 25,000 rounds of ammunition for erosion testing at this station.

WM. C. DAVIS
Chief Engineer

APPROVED:

BENJAMIN S. GOODWIN
Assistant Director
Engineering Testing
Development and Proof Services

G. A. GUSTAFSON
Chief
Infantry and Aircraft
Weapons Division

5 December 1955

SPECIAL NOTICE

The Development and Proof Services 35th Report on Project No. TS1-2 is being published for distribution at this time in incomplete form, Appendix C being omitted from the initial distribution. This has been made necessary in the interest of timely availability of the major portion of the data, and copies of Appendix C will be distributed separately as soon as they become available at Aberdeen Proving Ground.

As noted in Appendix A, an inquiry made on 23 September 55 elicited the estimate that the Army Chemical Center would publish during November 1955 the report which will comprise Appendix C. Reply to a verbal inquiry made 5 December 55, however, indicates that publication cannot be accomplished prior to about 1 January 56. It was felt that the remainder of the main report should not be further delayed, because some urgent requirements exist for information presented therein.

Some information obtained from a draft of the Army Chemical Center report during September 1955 has been included in the body of the main report. References by number and date to Appendix C have been left blank in the body of the main report, and can be entered by the custodians of the various copies when Appendix C has been received.

The author of the 35th Report on Project No. TS1-2 has reviewed a draft of the Army Chemical Center report, and discussed its contents with the authors of that report, and feels that the conclusions dealing with wound ballistics are adequately substantiated. However, final judgement on this aspect of the experimental work should probably be withheld until Appendix C can be distributed.

WM. C. DAVIS

APPENDICES

APPENDIX A	-	Correspondence
APPENDIX B	-	Round-by-Round Data
APPENDIX C	-	MIRR No. _____
APPENDIX D	-	Cartridge, Bullet, and Chamber Drawings (U)

APPENDIX A

Correspondence

TT ORD 1548 (Unc)
Ltr APG(o) 471/162 (Conf)
Ltr APG 471/1183 (Unc)

V 7 JAN 1955 20 18

1955 JAN 7 15 58

DEV & PROOF SERVICES
APG, MD

ET079

EUC201

RR UETGH

DE UEPDA 844

R 0719002

FM COFORD DA WASHDC

TO CG ABERDEEN PG MD
DA GRNC

FOR D AND PS CMM W C DAVIS FROM ORDTS CARTEN TT ORD 1548 RE FONECON CARTEN-DAVIS 6 JAN 55 CMM REQUEST TEST PROGRAM BE CONDUCTED TO EVALUATE CALIBER .22 SIERRA BULLETS FOR APPLICATION TO CALIBER .22 H V RIFLE PD REQUEST WOUND BALLISTICS TESTS FOR SAME BE ARRANGED WITH ARMY CHEMICAL CENTER PD COSTS CHARGEABLE TO PROJECT TS1-2

CFN 1548 6 55 .22 .22 TS1-2

07/1944

22

MrWCDavis/ps/22206

19 April 1955

APG(c) 471/162

ORDBG-DPS-AA

SUBJECT: Wound-Ballistic Investigation of Caliber .22 High-Velocity Rifle Ammunition

TO: Commanding General
Army Chemical Center
Maryland

1. In compliance with teletype ORD 1548 dated 7 January 1955, a copy of which is inclosed herewith, it is requested that the subject investigation be made at your station. It is suggested that the investigation be similar to that previously conducted by the Biophysics Division on the Caliber .22 Carbine bullet, and that data be furnished this station in a report similar to that prepared by Dr. A. J. Dziemian, of that Division, designated MLRR No. 334, dated December 1954, entitled "Wound Ballistics Assessment of the .30 Cal. Ball, Carbine, M1 and an Experimental .22 Cal. Ball Carbine." Ammunition, ammunition components, weapons required, exterior-ballistic data, and any further assistance necessary will be supplied by Development and Proof Services at this station. Representatives of D&PS at this station and the Chemical Corps Medical Laboratories at your station have discussed these details.

2. It is requested that distribution to this station of the report of the subject investigation include 20 copies for distribution as an appendix to the D&PS reports which will cover the overall tests of the experimental ammunition. These copies should be directed to the attention of Small Arms and Aircraft Weapons Branch, A&A Division, D&PS.

3. As noted in the inclosure herewith, costs for this program are chargeable to Project No. T81-2.

1 Incl
1. TT ORD 1548 dtd 7 Jan 55

Mr. WCDavis/mih/25288

23 September 1955

APG 471/1183

ORDBG-DP-TI

SUBJECT: Wound-Ballistic Investigation of Caliber .22 High-Velocity Rifle Ammunition

TO: Commanding General
Army Chemical Center
Maryland

ATTN: Dr. Rylander

REFERENCE: Letter, file APG (c)471/162, dated 19 April 1955, subject: as above.

1. With reference to paragraph 2. of the letter cited above, it is requested that the distribution of the report of the subject investigation be increased from twenty to thirty copies, and that these be directed to the Infantry and Aircraft Weapons Division, Development and Proof Services, at this station. The increased quantity has been made necessary by unforeseen additional distribution of the overall Development and Proof Services Report, and allows for approximately seven uncommitted copies in anticipation of further additions to the original distribution.

2. For purposes of planning the publication of the overall report, of which Dr. Dziemian's report will be an appendix, it would be helpful if some estimate could be given as to the probable date when copies of Dr. Dziemian's report will be available.

FOR THE DIRECTOR, DEVELOPMENT AND PROOF SERVICES:

Wm. C. DAVIS
Assistant

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CMLRE-ML (DI) 1st Ind
SUBJECT: Wound-Ballistic Investigation of Caliber .22 High-Velocity Rifle Ammunition (23 Sep 55)

APG 471/1183
CHEMICAL CORPS MEDICAL LABORATORIES, Army Chemical Center, Maryland 7 OCT 1955

TO: Director, Development and Proof Services, Aberdeen Proving Ground, Maryland

1. In reply to paragraph 1 of basic communication our distribution list will be corrected to include the 30 extra copies of subject report.

2. With reference to paragraph 2, as far as we know at this time Dr. Dziemian's report will be published in November.

FOR THE COMMANDING OFFICER:

/s/ Charles I. Harper, Capt Med.C.

CJH:gjc

for CHARLES O. MICHEAU
Lt Colonel, Cml C
Deputy

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APPENDIX B

Round-by-Round Data

Charge-Pressure and Charge Velocity Data
Accuracy Tests
Exterior-Ballistic Data
Penetration Tests
Stability Tests
Wound-Ballistic Tests
Cartridge, Chamber and Bullet Drawings (Uncl)

CHARGE-PRESSURE AND CHARGE-VELOCITY DATA

PRELIMINARY CHARGE-ESTABLISHMENT

DATE: 8 November 1954

TIME STARTED: 1400 TIME FINISHED: 1600

UNIVERSAL RECEIVER NO: 197 BARREL: 8-in. Twist

AMMUNITION TEMPERATURE: +70°F.

CHRONOGRAPH TYPE: Counter INITIATOR TYPE: Luminline

AMMUNITION: Cartridge, Ball, Cal..22 HV; Bullet, 68 grain, boattail
Propellant, 30mm, X487.2, AL 41362

ROUND NO.		INSTRUMENTAL VELOCITY at 78', fps.	PRESSURE psi	CHARGE Grains	REMARKS
1		2532	28,900	38	
2		2503	28,200		
3		2528	28,400		
4		2473	27,600		
5		2457	26,900		
6	AVG.	2499	28,000		
7		2796	Lost	43	
8		2875	33,700		
9		2849	33,200		
10		2872	33,600		
11		2852	33,600		
12		2849	33,525		
13		Lost	36,400	48	
14		3181	42,200		
15		3135	40,800		
16		Lost	41,600		
17		"	40,200		
18		3158	40,240		
19		3201	42,600	50	
20		3279	45,200		
21		3234	43,100		
22		3238	43,700		

PRESSURE TEST

DATE: 8 November 1954

TIME STARTED: 1400 TIME FINISHED: 1600

UNIVERSAL RECEIVER NO: 197 BARREL NO.: 8-in. Twist

AMMUNITION TEMPERATURE +70° F.

CHRONOGRAPH TYPE: Counter INITIATOR TYPE: Lanyard line

AMMUNITION: (Same as Page 1)

ROUND NO.	INSTRUMENTAL VELOCITY at 78', fps	PRESSURE psi	CHARGE Grains	REMARKS
1	3287	45,200	51	Normal case
2	3327	47,200		capacity
3	3307	46,000		
4	3307	46,133		
5	3413	50,100	53	Charge settled by stages during loading; over normal case capacity.
6	3351	47,100		
7	3358	48,000		
8	3374	48,400		

9 November 1954

VELOCITY TEST

TIME STARTED: 1325 TIME FINISHED: 1335

RIFLE: Accuracy, Cal. .22 HV BARREL: 10-in. Twist PREVIOUS RDS. 73

AMMUNITION TEMPERATURE: 70°F.

CHRONOGRAPH TYPE: Counter INITIATOR TYPE: Lumiline

TEST AMMUNITION: Bullet, ball, Cal. .22 HV, 68 grain boattail.
Chg. 51 grains XL87, AL 11362

RD NO.	INSTRUMENTAL VELOCITY at 78', fps	TARGET NO.	REMARKS		
1	3303	1	Accuracy 100 yards, indoor		
2	3351	Rds. 1-10)	Dimensions in inches		
3	3336				
4	3320				
5	3365				
6	3394				
7	3327				
8	3353				
9	3347		ES	HV	ES
10	3365		1.33	1.30	1.60
11	3333	2			
12	3420	(Rds.11-20)			
13	3376				
14	3383				
15	3420				
16	3358				
17	3333				
18	3358				
19	3396				
20	3399		1.45	1.00	1.50
AVG:	3362				
Ex.VAR:	117				
S. D:	31.8				

TEST OF VARIOUS CHARGES AND PRIMERS

DATE: 24 March 1955

UNIVERSAL RECEIVER NO: 197 GAUGE, PRESSURE: Cal. .22 HV, 8 inches/turn

BULLET: Ball, Cal. .22 HV, 68 Grain BT

CHARGE AND PRIMER:

SAMPLE A: 51 Grs. X487.5, with 0.56 grs.Tin Foil Added, WRA 120M Primer
SAMPLE B: 51 Grs. X892, Tin-Dioxide coated, Federal 215 Primer
SAMPLE C: 51 Grs. X487.5 with 0.56 Grs.Tin Foil Added, Federal 215 Primer

SAMPLE A			SAMPLE B			SAMPLE C		
ROUND NO.	PRESSURE, psi (Cu)	IV, fps at 78 ft.	ROUND NO.	PRESSURE psi (Cu)	IV, fps at 78 ft.	ROUND NO.	PRESSURE psi (Cu)	IV, fps at 78 ft.
1	45000	Lost	2	43400	3215	3	45200	3287
4	45200	3318	5	45000	3270	6	44700	3266
7	45600	3324	8	43600	3245	9	47000	3351
10	46400	3362	11	42600	3226	12	48400	3376
13	45700	3329	14	43000	3245	15	48500	3392
16	44000	3279	17	44400	3245	18	51200	3413
19	44700	3307	20	43000	3247	21	50500	3441
22	42600	3257	23	45400	3277	24	47200	3349
25	45600	3318	26	46200	3292	27	48400	3369
28	45700	3311	29	43000	3228	30	47700	3358
AVG.	45050	3312	AVG.	43960	3249	AVG.	47680	3360
Ex.VAR.	3800	105	Ex. VAR.	3600	77	Ex.VAR.	6500	175
S. D.	1030	28	S. D.	1160	23	S. D.	1930	50

DATE: 9 June 1955

VELOCITY TEST, EFFECT OF SHORTENING BARREL

RIFLE, ACCURACY, Cal..22 HV, RECEIVER NO. 4748532

TWIST: 10 in./Turn PREVIOUS ROUNDS: 10

CHARGE: 51.0 Grs. X-487.2

BULLET: 68-Gr. BT

INSTRUMENTAL VELOCITIES, fps AT 78 Feet

BARREL LENGTH: 27 In.		BARREL LENGTH: 22 In.	
RD. NO.	IV	RD. NO.	IV
1	3479	11	3399
2	3499	12	3309
3	3482	13	3333
4	3542	14	3378
5	3514	15	3331
6	3499	16	3360
7	3529	17	3381
8	3536	18	3385
9	3489	19	3399
10	3541	20	3378
AVG.	3509	AVG.	3365

PRESSURE TEST

TIME STARTED: 1510 TIME COMPLETED: 1545 DATE: 9 August 1955

UNIVERSAL RECEIVER NO: 197 BARREL NO. 1 (1 turn in 8 inches)

AMMUNITION TEMPERATURE : +70°F.

CHRONOGRAPH TYPE: Counter INITIATOR TYPE: Lumiline

TEST AMMUNITION: Case, Caliber .22 HV; Bullet 68-grain boattail;
Charge, 51 grains X-487.2 AL 4362; Primer, 120 M.
(INSTRUMENTAL S. P. Velocity, fps, is at 78 feet)
(PRESSURE, psi, is radial copper with undrilled cases.)

ROUND NO.	VELOCITY	PRESSURE
1	3324	51300
2	3309	50400
3	3369	53000
4	3338	51500
5	3360	51400
6	3347	50500
7	3381	53200
8	3401	52900
9	3383	51500
10	3360	51000
11	3392	52500
12	3401	51200
13	3392	52700
14	3376	52200
15	3401	53300
16	3378	50900
17	3413	53800
18	3392	52500
19	3376	50900
20	3399	53000
AVG.	3375	51985
VAR.	104	3400
S. D.	270	1010

ACCURACY TESTS

ACCURACY TEST

DATE: 7 December 1954 RANGE: 100 Yards, Indoors
FIRED FROM: Machine Rest

CARTRIDGE: Cal. .22 HV Rifle, with APG 68-Gr. Bullet, 42.0 Gr. IMR 4350
RIFLE: Accuracy. Cal. .22 HV. (Rifling as indicated)

Target measurements are given in inches for 10-shot groups

RIFLING	TARGET NO.	BULLET	MVD	MHD	ES
8-in.Twist	1	Cannelured	1.30	1.80	1.80
" "	2	Uncannelured	1.50	1.50	1.75
" "	AVG*	---	1.40	1.65	1.78
10-in.Twist	3	Cannelured	0.75	1.25	1.30
" "	4	Uncannelured	1.25	0.75	1.30
" "	AVG.	---	1.00	1.00	1.30
	GRAND AVG.	---	1.20	1.33	1.54

(FOR ADDITIONAL INFORMATION, VELOCITIES WERE MEASURED DURING ACCURACY FIRING; AVERAGE INSTRUMENTAL VELOCITIES AT 78 ft. ARE GIVEN FOR EACH 10-SHOT GROUP)

TARGET NO:	AVG. IV, fps.
1	3264
2	3254
3	3209
4	3232
AVG.	3240

ACCURACY TEST

DATE: 18 January 1955 RANGE: 600 Yards
FIRED FROM: Machine Rest DIRECTION OF FIRE: 0°
WIND: 3-9 fps, 30° to 120°

CARTRIDGE: Cal. .22 RV Rifle, with APG 68-Gr. Bullet, 51.0 Gr. WB 487.2
RIFLE: Accuracy, Cal. .22 HV, 10-inch Twist, No. 4747051

Target measurements are given in inches for 10-shot groups

TARGET NO.	MR	MVD	MHD	EVD	EHD	ES
1	3.2	2.8	2.1	10.4	6.9	11.1
2	4.1	3.3	1.9	13.5	6.5	13.5
3	4.1	3.2	1.7	13.2	7.4	13.5
4	12.6	7.9	7.9	47.8	33.5	49.2
(NOTE: INSPECTION OF BARREL SHOWED HEAVY FOULING; BORE WAS CLEANED WITH NITRO-SOLVENT AND BRONZE BRUSH BEFORE FURTHER FIRING.)						
5	2.7	1.6	1.4	6.3	9.8	9.8
6	4.6	3.6	2.5	15.4	12.4	18.6
* 7	---	---	---	40.	26.	48.

* One shot missed 6x6-foot target; approximate dimensions given are for nine shots only. Barrel showed heavy fouling; firing discontinued.

ACCURACY TEST

DATE: 1 September 1955 RANGE: 600 Yards
FIRED FROM: Machine Rest
WIND: Calm

CARTRIDGE: Cal. .22 HV Rifle, with APC 68-Gr. Bullet, 51.0 Grs. X 1487.2
RIFLE: Accuracy, Cal. .22 HV, Chrome-plated bore, 10-inch twist;
PREV.RDS. - 43

TARGET NO.	MR	MVD	MHD	EVD	EHD	ES
1	3.9	2.9	2.3	9.5	9.7	10.4
2	3.0	2.4	2.0	9.5	10.6	10.7
3	3.2	2.7	2.1	11.4	7.4	11.5
4	4.3	2.4	2.7	11.7	12.4	12.6
5	4.2	3.2	2.2	13.2	10.5	16.9
6	5.6	3.3	3.7	12.1	19.0	19.2
7	5.2	3.3	3.0	12.9	12.2	14.1
8	5.0	3.5	2.6	12.4	12.2	16.5
9	3.7	2.8	1.6	12.8	7.9	13.1
10	4.5	2.5	3.1	12.7	9.8	12.9
AVERAGE	4.26	2.90	2.53	11.82	11.17	13.79

ACCURACY TEST

DATE: 2 September 1955 RANGE: 600 Yards
FIRED FROM: Machine Rest
WIND: Calm

CARTRIDGE: Cal. .22 [illegible] with APC 68-Gr. Bullet, 51.0 grs. X 487.2
RIFLE: [illegible]

Target measurements are given in inches

TARGET NO.	MR	MVD	MHD	EVD	EHD	ES
11	3.9	3.4	1.4	13.9	4.9	14.0
12	4.1	1.6	3.1	8.8	15.6	15.8
13	5.2	3.9	2.8	16.5	15.1	18.5
14	6.6	5.1	3.3	17.4	13.5	17.5
15	4.8	3.0	3.1	10.3	13.4	15.0
16	4.3	2.5	2.9	13.3	10.3	15.8
17	4.8	3.8	2.0	11.9	10.0	13.8
18	4.5	1.8	3.6	7.5	16.9	17.0
19	5.9	4.9	2.8	16.1	12.3	19.3
AVERAGE	4.90	3.33	2.78	12.96	11.46	16.30

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ACCURACY TEST

DATE: 15 September 1955 RANGE: 600 Yards
FIRED FROM: Machine Rest
WIND: 0 - 10 mph

CARTRIDGE: Cal. .22 HV Rifle, with APG 68-Gr Bullet, 42.0 Gr. IMR 4350
RIFLE: Accuracy, Cal. .22 HV, Chrome-plated bore, 10-inch Twist;
R. F. Rd. - 251

Target measurements are given in inches

TARGET NO.	MR	MVD	MHD	EVD	EHD	ES
1	3.6	2.9	1.7	11.3	4.9	11.3
2	3.7	3.0	1.7	10.4	7.6	11.2
3	2.2	1.9	1.0	7.0	4.7	8.5
4	3.5	2.7	1.8	9.4	9.1	11.6
5	2.6	1.7	1.9	6.4	7.2	7.2
AVG.	3.1	2.4	1.6	8.9	6.7	10.0

EXTERIOR - BALLISTIC DATA

BALLISTIC-FIRING REPORTS AND BALLISTIC-COEFFICIENT COMPUTATION SHEETS

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Data from the following Ballistic-Firing Reports were reduced by Siacci methods in the manner described in the Twenty-eighth Report on Project No. TS1-2, yielding average ballistic coefficients with respect to $G_{5.1}$ as follows:

DATE FIRED	ROUNDS AVERAGED	RIFLING TWIST, Inches/turn	APPROXIMATE RANGE, Yards	BALLISTIC COEFFICIENT
21 Dec 54	10	10	0- to 200	.243
3 Jan 55	10	10	0 to 200	.237
21 Dec 54	10	10	0 to 600	.248
3 Jan 55	10	10	0 to 600	.251
21 Dec 54	12	10	0 to 1000	.239
21 Dec 54	10	8	0 to 1000	.245
30 Dec 54	10	10	0 to 1000	.239
30 Dec 54	10	8	0 to 1000	.242
3 Jan 55	9	10	0 to 1000	.239
3 Jan 55	10	8	0 to 1000	.243
12 Jan 55	10	10	0 to 2000	.248
12 Jan 55	11	8	0 to 2000	.245
17 Jan 55	2	10	0 to 2000	.249

A ballistic coefficient of $G_{5.1}$ = .244, which is a simple mean of the values above, and is also the grand average of the mean value obtained at each range, was used for all exterior ballistic calculations in this report.

BALLISTIC FIRING REPORT - Remaining Velocity			Date Fired: 21 December 1951
Caliber .30 M 1	Gun No. 4747051		Barrel 10-inch Twist
Cartridge Type and Lot: Special Ball with 68-gr. APC BT BULLET			
SCREEN DISTANCES FROM MUZZLE:	FIRST PAIR	Ft. 28.19	Ft. 79.75
	[illegible]	Ft. [illegible]	Ft. 420

Temperature 25.6 °F	Relative Atmospheric Density 1.089		
QUADRANT READINGS:	Boresight -13.5	Firing -13.4	Difference .1 Mil

Time Fired	Rd. No.	1st IV fps	2nd IV fps	Wind Vel. fps	Gun Wind Vector	Range Comp. Wind, fps	Remarks
1555	2	3247	2776	18	-0.4	-7.2	
	5	3257	2792	18	0.0	0.0	
	8	3230	2822	18	-0.1	-1.8	
	11	3301	2824	12	-0.8	-9.6	
	12	3342	2869	18	-0.7	-12.6	
	13	3272	2793	15	-0.3	-4.5	
	22	3290	2789	12	-0.3	-3.6	
	23	3290	2805	18	-0.2	-3.6	
	24	3289	2752	12	-0.2	-2.4	
1600	25	3241	2749	9	-0.5	-4.5	

BALLISTIC-COEFFICIENT COMPUTATIONS

Date Fired: 21 December Cartridge Type and Lot: Cal. .22 HV Date Computed: 22 December 1954

P = 1.089 T = 25.6 V.1/a = 1.0338, x = 546 ft., t = .19 sec (approx.) Drag Function G 5.1

(10-inch twist barrel)

Line No.		ROUND NUMBERS									
		2	5	8	11	12	13	22	23	24	25
1	V, fps	3247	3257	3269	3301	3342	3278	3290	3290	3289	3241
2	U, fps	2776	2798	2822	2824	2869	2795	2789	2805	2752	2749
3	W_x	-7	0	-2	-10	-13	- 4	- 4	- 4	- 2	- 5
4	$V-W_x$	3254	3257	3272	3311	3355	3276	3294	3294	3251	3246
5	$U-W_x$	2783	2798	2824	2834	2882	2799	2793	2809	2754	2754
6	$(V-W_x)/a$	3364	3367	3395	3425	3468	3387	3405	3405	3360	3356
7	$(U-W_x)/a$	2877	2896	2919	2950	2979	2892	2887	2904	2847	2847
8	$S(V-W_x)/a$	11998	11074	10948	10804	10507	10977	10890	10890	11205	11127
9	$S(U-W_x)/a$	13519	13473	13304	13247	12998	13448	13468	13581	13674	1367
10	$W_x t$	- 1	0	0	- 2	- 2	- 1	-1	- 1	0	- 1
11	$X-W_x t$	547	546	546	548	548	547	547	547	546	547
12	$P(X-W_x t)$	596	595	595	597	597	596	596	596	595	596
13	Lines (9)-(8)	2451	2399	2356	2443	2411	2465	2378	2491	2469	2547
14	C-Lines (12)/(13)	.245	.248	.253	.244	.248	.242	.251	.239	.241	.234

ORDBG-1655

Average $C_{5.1}$ = .243

BALLISTIC FIRING REPORT - Remaining Velocity

Date Fired: 3 January 1955

Caliber .22 RV | Gun No. 47h7051 | Barrel 10-inch twist

Cartridge Type and Lot
Special Ball with 68-gr. APG BT Bullet

SCREEN DISTANCES FROM MUZZLE: FIRST PAIR Ft. 28.38 Ft. 79.95

Ft. [illegible] Ft. 630

Temperature 48 °F | Relative Atmospheric Density 1.051

QUADRANT READINGS: Boresight -18.5 | Firing -17.7 | Difference .8 Mils

Time Fired	Rd. No.	1st IV fps	2nd IV fps	Wind Vel. fps	Ocs Wind Vector	Range Comp. Wind, fps	Remarks
1440	1	3336	2863	8	-.8	- 6	
	2	3310	2826	3	-.9	- 3	
	3	3404	2901	2	-.9	- 2	
	7	3295	2821	0	---	0	
	8	3319	2836	0	---	0	
	9	3321	2829	0	---	0	
	10	3321	2838	0	---	0	
	11	3312	2821	0	---	0	
	13	3342	2864	0	---	0	
1500	14	3399	2937	0	---	0	

BALLISTIC-COEFFICIENT COMPUTATION

Date Fired: 3 January 1955 Cartridge Type and Lot: CAL .22 HV Date Computed: 4 January 1955

P = 1.051 T = 48 °F.1/a= 1.0108 , x= 516 ft., t= .19 sec(approx.) Drag function 5.1

Line No.		ROUND NUMBERS: 1	2	3	7	8	9	10	11	13	14
1	V, fps	3356	3319	3404	3295	3319	3321	3321	3312	3342	3399
2	U, fps	2863	2888	2901	2821	2836	2829	2828	2821	2864	2937
3	W_x	- 6	- 3	- 2	0	0	0	0	0	0	0
4	$V-W_x$	3342	3313	3406	3295	3319	3321	3321	3312	3342	3399
5	$U-W_x$	2869	2891	2903	2821	2836	2829	2828	2821	2864	2937
6	$(V-W_x)/a$	3378	3349	3443	3331	3355	3357	3357	3348	3378	3436
7	$(U-W_x)/a$	2900	2868	2934	2851	2867	2860	2879	2851	2895	2969
8	$S(V-W_x)/a$	11021	11161	10708	11248	11192	11122	11122	11166	11021	10741
9	$S(U-W_x)/a$	13401	13597	13227	13654	13572	13607	13509	13654	13427	1304
10	$W_x t$	- 1	- 1	0	0	0	0	0	0	0	0
11	$X-W_x t$	547	547	516	516	516	516	516	516	516	516
12	$P(X-W_x t)$	575	575	574	574	574	574	574	574	574	574
13	Lines (9)-(8)	2380	2436	2519	2406	2439	2485	2387	2488	2406	2307
14	C-Lines (12)/(13)	.242	.236	.228	.239	.235	.231	.240	.231	.239	.249

ORDBC-1655

Average: $C_{5.1}$ = .237

BALLISTIC FIRING REPORT - Remaining Velocity

Date Fired: 21 December 1954

Caliber .22 H V	Gun No. 47L7051	Barrel 10-inch twist

Cartridge Type and Lot: Special Ball with 68-gr. AFG BT Bullet

SCREEN DISTANCES FROM MUZZLE:	FIRST PAIR	Ft. 28.19	Ft. 79.74
	SECOND PAIR	Ft. 1775	Ft. 1825

Temperature 26.2 °F	Relative Atmospheric Density 1.006

QUADRANT READINGS:	Boresight -9.8	Firing -6.2	Difference 3.6

Time Fired	Rd. No.	1st IV fps	2nd IV fps	Wind Vel. fps	Cos Wind Vector	Range Comp. Wind, fps	Remarks
1430	5	3298	1906	9	-0.5	-4.5	
	7	3290	1914	6	-0.4	-2.4	
	8	3296	1926	18	-0.1	-1.8	
	10	3281	1892	12	-0.3	-3.6	
	11	3363	1885	12	+0.7	8.4	
	12	3290	1866	7	+0.5	3.5	
	15	3309	1918	15	+0.1	1.5	
	17	3265	1906	12	-0.8	-9.6	
	18	3288	1895	18	-0.5	-9.0	
1430	20	3322	1941	12	-0.5	-6.0	

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BALLISTIC-COEFFICIENT COMPUTATION

Date Fired: 21 December 1954 Cartridge Type and Lot: Cal. .22 H V Date Computed: 22 December 1954

P = 1.006 T = 26.2 °F.1/a= 1.0336 , v= 1745 fs., t= .71 sec(approx.) Drag Function 5.1

(10-inch twist barrel

Line No.		ROUND NUMBERS 5	7	8	10	11	12	13	17	18	20
1	V, fps	3892	3890	3896	3881	3363	3890	3309	3263	3288	3322
2	U, fps	1906	1914	1926	1892	1885	1866	1918	1906	1895	1911
3	W_x	- 4	- 3	- 2	- 4	8	4	2	10	- 9	- 6
4	$V-W_x$	3896	3893	3898	3885	3355	3886	3307	3273	3297	3328
5	$U-W_x$	1910	1917	1928	1896	1877	1862	1916	1916	1904	1947
6	$(V-W_x)/a$	3407	3404	3409	3395	3468	3396	3418	3383	3408	3440
7	$(U-W_x)/a$	1974	1981	1993	1960	1940	1925	1980	1980	1968	2012
8	$S(V-W_x)/a$	10881	10895	10871	10939	10588	10934	10888	10997	10876	10722
9	$S(U-W_x)/a$	18487	18446	18374	18570	18689	18779	18451	18451	18523	18826
10	$W_x t$	- 3	- 2	- 1	- 3	6	3	1	- 7	- 6	- 4
11	$X-W_x t$	1749	1748	1747	1749	1740	1743	1745	1753	1752	1750
12	$P(X-W_x t)$	1899	1898	1897	1899	1890	1893	1895	1904	1903	1900
13	Lines (9)-(8)	7606	7551	7503	7631	8101	7845	7623	7454	7647	7540
14	C-Lines (12)/(13)	250	251	253	249	233	241	249	255	249	252

ORDBG-1655 Average: $C_{5.1}$ = .248

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BALLISTIC FIRING REPORT - Remaining Velocity			Date Fired: 3 January 1955
Caliber .22 HV	Gun No. 4747051		Barrel 10-inch twist
Cartridge Type and Lot: Special Ball with 68-gr. APG BT Bullet			
SCREEN DISTANCES FROM MUZZLE:	FIRST PAIR	Ft. 28.38	Ft. 79.91
	SECOND PAIR	Ft. 1775	Ft. 1825
Temperature 46.2 °F	Relative Atmospheric Density 1.054		
QUADRANT READINGS:	Boresight -9.3	Firing -5.3	Difference 4

Time Fired	Rd. No.	1st IV fps	2nd IV fps	Wind Vel. fps	Cos Wind Vector	Range Comp. Wind, fps	Remarks
1308	2	3375	2055	2	-.5	- 1	
	3	3307	1921	0	---	0	
1320	8	3355	1957	0	---	0	
	15	3316	1963	3	-.5	- 2	
	19	3331	1970	3	-1.0	- 3	
	20	3312	1957	6	-1.0	- 6	
	25	3342	1986	3	-1.0	- 3	
	26	3337	1969	3	-1.0	- 6	
	27	3359	2006	0	---	0	
1400	28	3340	1947	0	---	0	

BALLISTIC-COEFFICIENT COMPUTATION

Date Fired: 3 January 1955 Cartridge Type and Lot: Cal. .22 H V Date Computed: 4 January 1955

P = 1.0514 T = 46.2 T.1/a = 1.0126 , x = 1746 ft., t = .71 sec (approx.) Drag Function 5.1

Line No.		ROUND NUMBERS									
		2	3	8	15	19	20	25	26	27	28
1	V, fps	3315	3307	3355	3316	3331	3312	3342	3337	3359	3340
2	U, fps	2033	1921	1957	1963	1970	1957	1986	1963	2006	1947
3	W_x	- 1	0	0	- 2	- 3	- 6	- 3	- 6	0	0
4	$V-W_x$	3376	3307	3355	3318	3334	3318	3345	3343	3359	3340
5	$U-W_x$	2034	1921	1957	1965	1973	1963	1989	1969	2006	1947
6	$(V-W_x)/a$	3419	3349	3397	3360	3376	3360	3387	3385	3401	3382
7	$(U-W_x)/a$	2060	1945	1982	1990	1998	1988	2014	1994	2031	1972
8	$\Sigma(V-W_x)/a$	10925	11161	10989	11108	11030	11108	10977	10987	10910	11002
9	$\Sigma(U-W_x)/a$	17982	18630	18439	18392	18345	18404	18251	18369	18151	18496
10	$W_x t$	- 1	0	0	- 1	- 2	- 4	- 2	- 4	0	0
11	$X-W_x t$	1747	1746	1746	1747	1748	1750	1748	1750	1746	1746
12	P $(X-W_x t)$	1841	1840	1840	1841	1842	1844	1842	1844	1840	1840
13	Lines (9)-(8)	7159	7469	7510	7284	7315	7296	7274	7382	7241	7498
14	C-Lines (12)/(13)	.257	.246	.245	.253	.252	.253	.253	.250	.254	.245

ORDBG-1655

Average: $C_{5.1}$ = .251

BALLISTIC FIRING REPORT - Remaining Velocity			Date Fired: 21 December 1954
Caliber .22 H V	Gun No. 4747951		Barrel 10-inch twist
Cartridge Type and Lot: Special Ball with 68-gr. APC BT Bullet			
SCREEN DISTANCES FROM MUZZLE:	FIRST PAIR	Ft. 28.19	Ft. 79.73
	SECOND PAIR	Ft. 2980	Ft. 3020
Temperature 22.5 °F	Relative Atmospheric Density 1.097		
QUADRANT READINGS:	Boresight -6.0	Firing 5.0	Difference 11 Mils

Time Fired	Rd. No.	1st IV fps	2nd IV fps	Wind Vel. fps	Cos Wind Vector	Range Comp. Wind, fps	Remarks
1100	6	3260	1088	17	-0.2	-3.4	
	7	3242	1116	17	+0.6	10.2	
	8	3240	1132	17	-0.0	0.0	
1110	9	3256	1083	15	-0.5	-7.5	
	11	3242	1090	18	-0.3	-5.4	
	12	3270	1139	16	+0.3	4.8	
1115	13	3244	1113	17	-0.3	-5.1	
	15	3251	1144	18	+0.5	9.0	
	17	3264	1182	9	+0.4	3.6	
	18	3227	1101	5	+0.7	2.1	
	19	3250	1103	12	+0.4	2.8	
1120	20	3272	1141	18	+0.0	0.0	

BALLISTIC-COEFFICIENT COMPUTATION

Date Fired: 21 December 1954 Cartridge Type and Lot: Cal. .22 K V Date Computed: 22 December 1954

P = 1.097 T = 28.5 V.1/a= 1.0371 , x= 2946 ft., t= 1.6 sec(approx.) Drag Function 5.1

(10-inch twist barrel)

Line No.		ROUND NUMBERS 6	7	8	9	11	12	13	15	17	18
1	V,fps	3260	3242	3240	3256	3242	3270	3244	3231	3264	3227
2	U,fps	1088	1116	1132	1083	1090	1139	1113	1114	1122	1101
3	W_x	- 3	10	0	- 8	- 5	5	- 5	9	4	2
4	$V-W_x$	3263	3232	3240	3264	3247	3265	3249	3222	3260	3225
5	$U-W_x$	1091	1106	1131	1091	1095	1134	1118	1135	1118	1099
6	$(V-W_x)/a$	3384	3352	3360	3385	3367	3386	3370	3342	3381	3345
7	$(U-W_x)/a$	1131	1147	1174	1131	1136	1176	1159	1177	1159	1140
8	$\Sigma(V-W_x)/a$	10992	11146	11167	10987	11074	10982	11099	11195	11006	11180
9	$\Sigma(U-W_x)/a$	21841	21655	21364	21841	21781	21343	21522	21332	21522	21735
10	W_x%	- 5	16	0	- 13	- 8	8	- 8	14	6	3
11	$X-W_x$%	2951	2930	2946	2959	2954	2938	2954	2932	2940	2943
12	P $(X-W_x$%)	3237	3214	3232	3246	3241	3223	3241	3216	3225	3228
13	Lines (9)-(8)	13849	13509	13857	13854	13707	13361	13463	13137	13516	13555
14	C-Lines (12)/(13)	.254	.238	.214	.254	.236	.241	.241	.245	.239	.238

ORDBB-1655

Average: $C_{5.1}$ = .239

BALLISTIC-COEFFICIENT COMPUTATION

Date Fired: 21 December 1954 Cartridge Type and Lot: Cal..22 HV Date Computed: 22 December 1954

P = 1.027 T = 22.5 °F. 1/a= 1.6371 , x= 2916 ft., t= 1.6 sec(approx.) Drag Function 5.1

(10-inch twist barrel)

Line No.		ROUND NUMBERS									
		19	20								
1	V, fps	3860	3872								
2	U, fps	1103	1141								
3	W_x	3	6								
4	$V-W_x$	3857	3872								
5	$U-W_x$	1100	1141								
6	$(V-W_x)/a$	3578	3595								
7	$(U-W_x)/a$	1141	1183								
8	$S(V-W_x)/a$										
9	$S(U-W_x)/a$										
10	$W_x t$										
11	$X-W_x t$										
12	$P(X-W_x t)$										
13	Lines (9)-(8)										
14	C-Lines (12)/(13)										

CRDBG-1655

BALLISTIC FIRING REPORT - Remaining Velocity			Date Fired: 21 December 1954
Caliber .22 H V	Gun No. 1468719		Barrel 8-inch Twist
Cartridge Type and Lot: Special Ball with 68-gr. AFC BT Bullet			
SCREEN DISTANCES FROM MUZZLE:	FIRST PAIR	Ft. 28.19	Ft. 79.73
	SECOND PAIR	Ft. 2980	Ft. 3020
Temperature 23.2 °F	Relative Atmospheric Density 1.095		
QUADRANT HEADINGS:	Boresight -6.0	Firing 4.0	Difference 10 Mils

Time Fired	Rd. No.	1st IV fps	2nd IV fps	Wind Vel. fps	Cos Wind Vector	Range Comp. Wind, fps	Remarks
1125	1	3310	1134	15	+0.3	4.5	
	2	3314	1125	20	-0.3	-6.0	
	3	3292	1154	16	-0.2	-3.2	
	5	3283	1166	15	+0.5	7.5	
	7	3264	1159	8	-0.2	-1.6	
	8	3330	1174	6	+0.0	0.0	
	15	3306	1170	12	-0.1	-1.2	
	20	3262	1169	9	+0.1	0.9	
	21	3340	1204	15	+0.7	10.5	
1200	22	3254	1147	15	+0.1	1.5	

BALLISTIC-COEFFICIENT COMPUTATION

Date Fired: 21 December 1954 Cartridge Type and Lot: .22 H V Date Computed: 22 December 1954

P = 1.095 T = 81.2 V.1/a= 1.1764, x= 2546 ft., t= 1.6 sec(approx.) Drag Function 5.1

(8-inch twist barrel)

Line No.		ROUND NUMBERS									
		1	2	3	5	7	8	15	20	21	22
1	V,fps	3840	3844	3838	3885	3866	3330	3306	3262	3340	3284
2	U,fps	1134	1188	1154	1166	1159	1174	1170	1169	1204	1147
3	W_x	5	- 6	- 3	7	- 2	0	- 1	1	11	1
4	$V-W_x$	3835	3850	3855	3876	3868	3330	3307	3261	3329	3293
5	$U-W_x$	1189	1189	1157	1159	1161	1174	1171	1180	1193	1146
6	$(V-W_x)/a$	3353	3368	3373	3395	3387	3451	3427	3380	3450	3433
7	$(U-W_x)/a$	1170	1170	1199	1201	1205	1217	1214	1223	1236	1188
8	$S(V-W_x)/a$	111142	11869	11845	10939	10977	10670	10785	11011	10674	10952
9	$S(U-W_x)/a$	24105	24105	24112	24092	24072	23957	23966	23879	23756	24227
10	$W_x t$	8	-10	- 5	11	- 3	0	- 2	2	18	2
11	$X-W_x t$	2938	2956	2951	2935	2949	2946	2948	2544	2928	2944
12	$P(X-W_x t)$	3217	3237	3231	3214	3229	3226	3228	3224	3206	3224
13	Lines (9)-(8)	13863	13336	13067	13153	13095	13267	13181	12868	13082	13369
14	C-Lines (12)/(13)	.243	.243	.247	.244	.247	.243	.245	.251	.245	.241

Average: $C_{5.1} = .245$

BALLISTIC FIRING REPORT - Remaining Velocity			Date Fired: 30 December 1954
Caliber .22 RV	Gun No. 4747051		Barrel 10-inch twist
Cartridge Type and Lot: Special Ball with 68-gr. APC BT Bullet			
SCREEN DISTANCES FROM MUZZLE:	FIRST PAIR	Ft. 28.25	Ft. 79.75
	SECOND PAIR	Ft. 2980	Ft. 3080
Temperature 90 °F	Relative Atmospheric Density 1.033		
QUADRANT READINGS:	Boresight - 9.2	Firing 3.2	Difference 12.4

Time Fired	Rd. No.	1st IV fps	2nd IV fps	Wind Vel. fps	Cos Wind Vector	Range Comp. Wind, fps	Remarks
1115	1	3361	1182	20	-.4	-8	
	3	3331	1191	12	-.7	-8	
	6	3331	1212	16	-.3	-4	
	7	3314	1208	18	-.7	-13	
	8	3349	1227	20	-.8	-16	
	10	3329	1245	15	-.6	- 9	
	11	3327	1184	18	0	0	
1125	12	3353	1213	18	-.6	- 11	
	13	3338	1255	18	-.9	- 16	
1125	14	3318	1197	18	-.3	- 5	

BALLISTIC-COEFFICIENT COMPUTATION

Date Fired: 30 December 1954 Cartridge Type and Lot: Cal. .22 H V Date Computed: 4 January 1955

P = 1.053 T = 50 P.1/a= 1.0888, x= 8546 ft., t= 1.6 sec(approx.) Drag Function 5.1

10-inch Barrel

Line No.		ROUND NUMBERS									
		1	3	6	7	8	10	11	12	13	14
1	V,fps	3302	3331	3331	3314	3349	3329	3327	3351	3338	3318
2	U,fps (2120)	1182	1191	1202	1208	1227	1245	1184	1211	1235	1197
3	W_x	- 8	- 8	- 4	-13	-16	- 9	0	- 11	- 16	- 5
4	$V-W_x$	3309	3339	3335	3327	3365	3338	3327	3364	3354	3323
5	$U-W_x$	1190	1199	1216	1221	1243	1254	1184	1222	1251	1202
6	$(V-W_x)/a$	3358	3388	3364	3356	3395	3367	3356	3394	3384	3352
7	$(U-W_x)/a$	1200	1210	1227	1232	1254	1265	1196	1233	1262	1213
8	$S(V-W_x)/a$	11214	11069	11088	11127	16912	11074	11127	10943	10992	11147
9	$S(U-W_x)/a$	24102	24004	23841	25734	23509	25488	24161	25705	25516	23977
10	$W_x t$	- 13	- 13	- 6	-21	-26	-14	0	-18	-26	- 8
11	$X-W_x t$	2959	2959	2952	2967	2972	2960	2946	2964	2972	2954
12	$P(X-W_x t)$	3057	3057	3049	3065	3070	3058	3043	3062	3070	3051
13	Lines (9)-(8)	12888	12935	12753	12667	12651	12414	13054	12812	12524	12828
14	C-Lines (12)/(13)	.257	.256	.239	.242	.243	.246	.233	.238	.238	.238

ORDBG-1655 Average: $C_{5.1}$ = .239

BALLISTIC FIRING REPORT - Remaining Velocity

Date Fired: 30 December 1954

Caliber .22 H V

Gun No. 1468719

Barrel 8-inch Twist

Cartridge Type and Lot

Special Ball with 68-gr. APC BT Bullet

SCREEN DISTANCES FROM MUZZLE:

FIRST PAIR	Ft. 28.25	Ft. 79.75
SECOND PAIR	Ft. 2980	Ft. 3020

Temperature 50 °F

Relative Atmospheric Density 1.033

QUADRANT READINGS:

Boresight	Firing	Difference
- 9.2	2.2	11.4

Time Fired	Rd. No.	1st IV fps	2nd IV fps	Wind Vel. fps	Cos Wind Vector	Range Comp. Wind, fps	Remarks
1050	6	3346	1243	18	-.2	- 4	
	9	3368	1282	22	-.2	- 4	
	11	3415	1276	15	-.5	- 7	
1055	12	3402	1261	15	+.1	2	
	14	3368	1236	15	+.2	3	
	16	3420	1271	22	-.3	- 7	
1110	21	3370	1255	18	-.1	- 2	
	23	3357	1260	22	-.5	-11	
	24	3386	1240	16	-.3	- 5	
1112	25	3346	1232	20	+.2	4	

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BALLISTIC-COEFFICIENT COMPUTATION

Date Fired: 30 December 1954 Cartridge Type and Lot: Cal. .22 H V Date Computed: 4 January 1955

P = 1.033 T = 50 °F. I/s= 1.0038 , x= 2946 ft., t= 1.6 sec(approx.) Drag Function 5.1

8-inch Barrel

Line No.		ROUND NUMBERS									
		6	9	11	12	14	16	21	23	24	25
1	V, fps	3346	3368	3415	3402	3368	3420	3370	3357	3386	3346
2	U, fps (2124)	1283	1292	1276	1261	1296	1271	1235	1260	1240	1252
3	W_x	- 4	- 4	- 7	2	3	- 7	- 2	- 11	- 5	4
4	$V-W_x$	3350	3372	3422	3400	3365	3427	3372	3368	3391	3342
5	$U-W_x$	1287	1296	1283	1259	1293	1278	1237	1271	1245	1288
6	$(V-W_x)/a$	3379	3402	3452	3430	3395	3457	3402	3398	3421	3371
7	$(U-W_x)/a$	1298	1297	1294	1270	1214	1289	1248	1282	1256	1239
8	$\Sigma(V-W_x)/a$	11016	10905	11147	10770	10459	10641	10905	10924	10813	11050
9	$\Sigma(U-W_x)/a$	23552	23803	23889	23443	23682	23273	23645	23336	23572	23728
10	$W_x t$	- 6	- 6	- 11	3	5	- 11	- 3	- 18	- 8	6
11	$X-W_x t$	2952	2952	2957	2943	2941	2957	2949	2964	2954	2940
12	P $(X-W_x t)$	3049	3049	3055	3040	3038	3055	3046	3062	3051	3037
13	Lines (9)-(8)	12536	12898	12082	12673	13223	12632	12740	12412	12758	13678
14	C-Lines (12)/(13)	.243	.238	.253	.240	.230	.242	.239	.247	.239	.210

OEDBG-1655

Average: $C_{5.1}$ = .242

BALLISTIC FIRING REPORT - Remaining Velocity			Date Fired: 3 January 1955
Caliber .22 H V	Gun No. 4747051		Barrel 10-inch Twist
Cartridge Type and Lot: Special Ball with 68-gr. APG HT Bullet			
SCREEN DISTANCES FROM MUZZLE:	FIRST PAIR	Ft. 28.38	Ft. 79.91
	SECOND PAIR	Ft. 2980	Ft. 3020
Temperature 47 °F	Relative Atmospheric Density 1.055		
QUADRANT READINGS:	Boresight -6.6	Firing 3.0	Difference 9.6

Time Fired	Rd. No.	1st IV fps	2nd IV fps	Wind Vel. fps	Cos Wind Vector	Range Comp. Wind, fps	Remarks
1105	2	3383	1190	18	+.4	4	
	3	3380	1187	6	+.8	5	
	5	3383	1281	5	+.4	2	
1139	6	3316	1189	4	+.8	3	
	13	3312	1195	4	0	0	
	16	3377	1211	0	---	0	
	17	3314	1202	4	+.5	2	
	18	3293	1168	0	---	0	
1125	19	3268	1172	0	---	0	

BALLISTIC-COEFFICIENT COMPUTATION

Date Fired: 3 January 1955 Cartridge Type and Lot: Cal. .22 H V Date Computed: 4 January 1955

P = 1.055 T = 47 V.1/a= 1.0118 , x= 2946 ft., t= 1.6 sec(approx.) Drag Function 5.1

10-inch Barrel

Line No.		ROUND NUMBERS									
		2	3		5	6	13	16	17	18	19
1	V,fps	3385	3320		3385	3318	3312	3377	3314	3293	3288
2	c,fps 2152	1190	1187		1221	1189	1195	1211	1202	1168	1172
3	W_x	4	5		8	3	0	0	2	0	0
4	$V-W_x$	3379	3315		3381	3315	3312	3377	3312	3293	3288
5	$U-W_x$	1186	1182		1219	1186	1195	1211	1200	1168	1172
6	$(V-W_x)/a$	3419	3354		3421	3354	3351	3417	3351	3332	3327
7	$(U-W_x)/a$	1200	1196		1233	1200	1209	1225	1214	1182	1186
8	$S(V-W_x)/a$	10883	11137		10813	11137	11151	10853	11151	11243	11268
9	$S(U-W_x)/a$	24102	24141		25765	24102	24024	25860	25966	24282	24241
10	W_x*	6	8		3	5	0	0	3	0	0
11	$X-W_x$*	2940	2938		2943	2941	2946	2946	2943	2946	2946
12	P (X--> ∞)	3102	3100		3105	3103	3108	3108	3105	3108	3108
13	Lines (9)-(8)	13873	13004		12978	12965	12863	13027	12815	13039	12973
14	C-Lines (12)/(13)	.284	.238		.239	.239	.242	.239	.243	.238	.240

OEDBG-1655 Average: $C_{5.1}$ = .239

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BALLISTIC FIRING REPORT — Remaining Velocity — Date Fired: 3 January 1955

Caliber .22 RV | Gun No. 1168719 | Barrel 8-inch twist

Cartridge Type and Lot: Special Ball with 68-gr. APG BT Bullet

SCREEN DISTANCES FROM MUZZLE:		
FIRST PAIR	Ft. 26.38	Ft. 79.91
SECOND PAIR	Ft. 2980	Ft. 3020

Temperature 47 °F | Relative Atmospheric Density 1.055

QUADRANT READINGS:	Boresight	Firing	Difference
	-6.6	2.7	9.3

Time Fired	Rd. No.	1st IV fps	2nd IV fps	Wind Vel. fps	Cos Wind Vector	Range Comp. Wind, fps	Remarks
1032	6	3408	1260	0	---	0	
	8	3417	1270	0	---	0	
	17	3404	1220	6	-.4	- 2	
	19	3401	1252	6	+.4	2	
1055	20	3370	1225	6	+.8	5	
	21	3327	1253	6	+.7	4	
	22	3375	1220	5	+.6	3	
	23	3454	1305	9	+.5	5	
	25	3401	1248	3	+.3	1	
2055	26	3382	1194	0	0	0	

BALLISTIC-COEFFICIENT COMPUTATION

Date Fired: 3 January 1955 Cartridge Type and Lot: Cal. .22 H V Date Computed: 4 January 1955

P = 1.055 T = 47 °F.1/a= 1.0118, x= 2946 ft., t= 1.6 sec(approx.) Drag Function 5.1

8-inch Barrel

Line No.		ROUND NUMBERS									
		6	8	17	19	20	21	22	23	25	26
1	V,fps	3408	3417	3404	3401	3370	3327	3375	3454	3401	3322
2	U,fps	1280	1270	1280	1258	1213	1233	1220	1305	1248	1134
3	W_x	0	0	- 2	2	5	4	3	5	1	0
4	$V-W_x$	3408	3417	3406	3399	3365	3323	3372	3449	3400	3322
5	$U-W_x$	1280	1270	1282	1258	1218	1229	1217	1300	1247	1134
6	$(V-W_x)/a$	3448	3457	3446	3439	3405	3362	3412	3490	3440	3361
7	$(U-W_x)/a$	1295	1285	1296	1265	1232	1243	1231	1315	1262	1208
8	$S(V-W_x)/a$	10684	10641	10694	10727	10890	11098	10857	10483	10732	11103
9	$S(U-W_x)/a$	25220	25309	25756	25489	25794	23691	23684	23046	23516	21001
10	$W_x t$	0	0	- 3	3	8	6	5	8	2	0
11	$X-W_x t$	2946	2946	2949	2943	2938	2940	2941	2938	2944	2946
12	$P(X-W_x t)$	3108	3106	3111	3105	3100	3102	3103	3100	3106	3108
13	Lines (9)-(8)	12536	12668	13062	12762	12904	12593	12947	12563	12794	12901
14	C-Lines (12)/(13)	.248	.245	.238	.243	.240	.246	.240	.247	.243	.241

OEDBG-1655 Average: $C_{5.1}$ = .243

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BALLISTIC FIRING REPORT - Remaining Velocity			Date Fired: 12 January 1955
Caliber .22 H V	Gun No. 4747051		Barrel 10-inch twist
Cartridge Type and Lot: Special Ball with 68-gr. APG BT Bullet			
SCREEN DISTANCES FROM MUZZLE:	FIRST PAIR	Ft. 28.38	Ft. 79.96
	SECOND PAIR	Ft. 5995	Ft. 6005
Temperature 55 °F	Relative Atmospheric Density 1.073		
QUADRANT READINGS:	Boresight -4.6	Firing 44.2	Difference 48.8 Mils

Time Fired	Rd. No.	1st IV fps	2nd IV fps	Wind Vel. fps	Cos Wind Vector	Range Comp. Wind, fps	Remarks
1410	24	3356	714	15	-1.0	-15	
1420	29	3382	736	12	-0.9	-11	
1425	33	3356	716	9	-0.9	- 8	
	34	3367	725	6	-0.9	- 5	
	36	3309	727	6	-1.0	- 6	
	39	3317	712	3	-1.0	- 3	
	41	3386	725	3	-1.0	- 3	
	47	3371	729	3	-1.0	- 3	
	49	3345	720	3	-1.0	- 3	
1445	55	3345	720	9	-0.9	- 8	

BALLISTIC-COEFFICIENT COMPUTATION

Date Fired: 12 January 1955 Cartridge Type and Lot: Cal. .22 H V Date Computed: 13 January 1955

P = 1.073 T = 33 T.1/a= 1.0861 , x= 5946 ft., t= 5 sec(approx.) Drag Function G 5

10-inch Barrel

Line No.		ROUND NUMBERS 24	89	33	34	36	39	41	47	49	55
1	V, fps	3336	3362	3336	3367	3309	3317	3326	3371	3292	3345
2	U, fps	714	736	716	715	717	712	725	729	730	720
3	W_x	- 15	- 11	- 8	- 5	- 6	- 3	- 3	- 3	- 3	- 8
4	$V-W_x$	3351	3313	3344	3372	3315	3320	3329	3374	3295	3353
5	$U-W_x$	729	747	724	728	733	715	728	732	733	728
6	$(V-W_x)/a$	3438	3399	3390	3460	3402	3407	3416	3462	3381	3441
7	$(U-W_x)/a$	748	766	743	747	752	734	747	751	752	747
8	$S(V-W_x)/a$	10732	10919	10963	10686	10985	10852	10799	10617	11006	10717
9	$S(U-W_x)/a$	36733	39951	36955	36777	36558	37392	36777	36602	36558	367
10	$W_x t$	- 75	- 55	- 40	- 25	- 30	- 15	- 15	- 15	- 15	- 40
11	$X-W_x t$	6021	6001	5986	5971	5976	5961	5961	5961	5961	5986
12	$F(X-W_x t)$	6461	6439	6423	6407	6412	6396	6396	6396	6396	6423
13	Lines (9)-(8)	26001	25032	25990	26151	25653	26500	25978	25985	25552	26060
14	C-Lines (12)/(13)	.248	.257	.247	.245	.250	.241	.246	.246	.250	.246

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Average: $C_{5.1}$ = .246

BALLISTIC FIRING REPORT - Remaining Velocity			Date Fired: 12 January 1955
Caliber .22 H V	Gun No. 1468719		Barrel 8-inch twist
Cartridge Type and Lot	Special Ball with 68-gr. APC BT Bullet		
SCREEN DISTANCES FROM MUZZLE:	FIRST PAIR	Ft. 28.38	Ft. 79.96
	SECOND PAIR	Ft. 5995	Ft. 6005
Temperature 53 °F	Relative Atmospheric Density 1.073		
QUADRANT READINGS:	Boresight -4.6	Firing 43.2	Difference 47.8 Mils

Time Fired	Rd. No.	1st IV fps	2nd IV fps	Wind Vel. fps	Ccs Wind Vector	Range Comp. Wind, fps	Remarks
1500	6	3311	727	0	---	0	
	8	3380	711	0	---	0	
	10	3388	726	0	---	0	
1510	19	3339	732	0	---	0	
	20	3349	730	3 [illegible]	-1.0	- 3	
1520	27	3354	743	9	-1.0	- 9	
	41	3405	736	0	---	0	
1540	43	3356	706	3	-1.0	- 3	
	45	3369	735	2	-1.0	- 2	
	46	3380	732	0	---	0	
1545	49	3341	732	0	---	0	

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BALLISTIC-COEFFICIENT COMPUTATION

Date Fired: 12 January 1955 Cartridge Type and Lot: Cal. .22 H V Date Computed: 13 January 1955

P = 1.073 T = 33 °F. 1/a = 1.0161, x = 5946 ft., t = 5 sec (approx.) Drag Function G 5

8-inch Barrel

Line No.		48	ROUND NUMBERS 6	8	10	19	20	27	41	43	45	46
1	V, fps	3341	3311	3300	3308	3339	3349	3354	3425	3336	3369	3320
2	U, fps	732	727	711	786	732	730	743	736	706	733	722
3	W_x	0	0	0	0	0	- 3	- 9	0	- 3	- 2	0
4	$V-W_x$	3341	3311	3300	3328	3339	3352	3363	3425	3339	3371	3320
5	$U-W_x$	732	727	711	726	732	733	752	736	709	735	722
6	$(V-W_x)/a$	3426	3397	3468	3415	3426	3439	3451	3514	3447	3459	3407
7	$(U-W_x)/a$	751	746	730	745	751	752	772	755	727	754	741
8	$S(V-W_x)/a$	10780	10929	10588	10842	10789	10727	10669	10369	10689	10631	10681
9	$S(U-W_x)/a$	36602	36821	37531	36865	36602	36558	35693	36427	37665	36471	37045
10	$W_x t$	0	0	0	0	0	- 15	- 45	0	- 15	- 10	0
11	$X-W_x t$	5946	5946	5946	5946	5946	5961	5991	5946	5961	5956	5946
12	$P(X-W_x t)$	6380	6380	6380	6380	6388	6396	6428	6390	6396	6391	6380
13	Lines (9)-(8)	25822	25892	26943	26023	25813	25831	25025	26058	26976	25840	26161
14	C-Lines (12)/(13)	.247	.246	.237	.245	.247	.248	.257	.245	.237	.247	.244

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Average: C_5 = .245

BALLISTIC FIRING REPORT - Remaining Velocity					Date Fired: 17 January 1955
Caliber .22 H V		Gun No. 4747051			Barrel 10-inch
Cartridge Type and Lot: Special Ball with 68-gr. APG BT Bullet					
SCREEN DISTANCES FROM MUZZLE:		FIRST PAIR	Ft. 28.35		Ft. 79.93
		SECOND PAIR	Ft. 5995		Ft. 6005
Temperature 33 °F		Relative Atmospheric Density 1.073			
QUADRANT READINGS:		Boresight - 5	Firing 42		Difference 47 Mils

Time Fired	Rd. No.	1st IV fps	2nd MV fps	Wind Vel. fps	Cos Wind Vector	Range Comp. Wind, fps	Remarks
1518	54	3349	732	12	- 0.4	- 5	
1520	64	3402	747	12	- 0.4	- 5	

BALLISTIC-COEFFICIENT COMPUTATION

Date Fired: 17 January 1955 Cartridge Type and Lot: .22 H V Date Computed: 17 January 1955

P = 1.064 T = 37.4 T.1/a= 1.0815 , x= 5946 ft., t= 5 sec(approx.) Drag Function G_5

10-inch Barrel

ROUND NUMBERS

Line No.		54	64								
1	V,fps	3349	3402								
2	U,fps	732	747								
3	W_x	- 5	- 5								
4	$V-W_x$	3354	3407								
5	$U-W_x$	737	752								
6	$(V-W_x)/a$	3406	3460								
7	$(U-W_x)/a$	753	768								
8	$\delta(V-W_x)/a$	10789	10531								
9	$\delta(U-W_x)/a$	36514	35864								
10	$W_x t$	- 25	- 25								
11	$X-W_x t$	5971	5971								
12	$P\ (X-W_x t)$	6353	6353								
13	Lines (9)-(8).	25725	25333								
14	C-Lines (12)/(13)	.247	.251								

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PENETRATION TESTS

Results given approximately as defined in ORD-M608-PM, Volume III, OPM 7-17:

Complete perforation (C. Perf.) - Bullet passes through plate, or one or both sides of helmet (W/o liner), as indicated.

Complete penetration (C. P.) - Bullet opens visible crack through plate or first side of helmet, but does not pass through plate or enter helmet.

Partial Penetration (P. P.) - Bullet strikes fairly but does not produce a C. P. or C. Perf.

Fair hit - Any impact on target not within one inch of edge of plate (or periphery of projected area of helmet), and not within distorted area from a previous impact on the same target.

PROOF SHEET 21 September 1955

Plate Penetration

.30 Cal. Ball, M2, Lot FA 4191

RANGE: 100 Yards
TARGET: 1/4 Homo. Plate BHN 364
5 rds. Fired for Locators and Warmers

TIME	ROUNDS	NO. RDS	
1135	1 - 5	5	* C. Perf.

RANGE: 150 Yards
TARGET: 1/4 Homo. Plate BHN 364
5 rounds Fired for Locaters and Warmer

1245	1 - 6	5	** P. P.

1 round lost, hit a previous hole

* C. Perf. = Complete perforation

**P. P. = Partial Penetration

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PROOF SHEET 20 September 1955

Plate Penetration

.22 Cal. Ball, Test Ammunition

RANGE: 300 Yards
TARGET: 1/4 Homo. Plate BHN 364
5 rounds Fired for Locators and Warmers - 12 Mils

TIME	ROUNDS		
1450	1 - 5	5 C. Perf.	

RANGE: 350 Yards 21 September 1955
2 rounds Fired for Locators - 11.5 Mils

1050	1 - 5	4 C. Perf. 1 P. P.	

RANGE: 400 Yards
5 rounds Fired for Locators - 9.6 Mils

1530	1 - 5	3 C. Perf. 2 P. P.	

RANGE: 450 Yards 20 September 1955
2 rounds Fired for Locators - 8 Mils

1000	1 - 5	5 P. P.	

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PROOF SHEET 22 September 1955

Helmet Penetration

.22 Cal. Ball, Test Ammunition

RANGE: 1000 Yards
TARGET: Steel Helmets + 2.4 Mils
3 rounds Fired for Locators

TIME	ROUNDS	
1040	1 - 6	1 C. Perf. through both sides of Helmet
		1 C. Perf. on Front, struck rim on back of helmet.
1044	7 - 11	No Fair hits
1046	12 - 16	1 C. Perf., on Front, Bulge on rear of helmet
1050	17-21	1 C. Perf., on Front, Bulge on rear of helmet
		1 C. Perf., on Front, struck rim on rear of helmet.

RANGE: 1100 Yards
TARGET: Steel Helmets + 5.4 Mils

1359	1 - 5	No Hits Fair or otherwise
1405	3 - 6	1 C. Perf., out bottom of helmet, missed rear + 3.4 Mils
		1 P. P. Dented Front
1410	6 - 11	1 P. P. Dented Front
1418	12 - 16	No Fair Hits
1427	17 - 25	2 P. P., Dented Front

PROOF SHEET 22 September 1955

Helmet Penetration

.30 Cal. Ball, M2, Lot FA 4191

RANGE: 1000 Yards + 8.5 Mils
TARGET: Steel Helmets
3 rounds Fired for Locators

TIME	ROUNDS	
1115	1 - 6	1 P. P. - Dent on Front of Helmet 5 rounds - No Fair Hits
1120	7 - 11	1 P. P. - Dent on Front of Helmet 4 rounds - No Fair Hits
1126	12 - 16	1 P. P. - Dented Front of Helmet 2 C. P. - Cracked Front of Helmet

RANGE: 900 Yards + 5 Mils
TARGET: Steel Helmets

1245	1 - 5	No Fair Hits
1251	6 - 10	1 P. P., Dent on Front of Helmet
1255	10 - 15	1 C. Perf. Bulge on Rear of Helmet 2 P. P., Dent on Front of Helmet
1305	16 - 20	No Fair Hits
1309	20 - 25	*** 2 C. P., Cracked Front of Helmet

*** Complete Penetration; cracked through front, but bullet did not enter helmet.

PINE-BOARD PENETRATION AT 2000 Yards

DATE: 17 January 1955

RIFLE: Accuracy, Caliber .22 HV, with 10-inch Twist

BULLET: Ball, Special, Caliber .22, 68-Grain Boat-Tail

CHARGE: 51 Grs. X 487.2 ; Approximate MV: 3400 fps.

TEMPERATURE: 37.4°F.

REL. ATM. DENSITY: 1.064

TARGET: Three courses of one-inch boards,
One inch between courses.

NUMBER OF FAIR HITS:	9
COMPLETE PERFORATIONS OF ALL THREE COURSES:	8
C. PERF: OF TWO COURSES, 3/4 PENETRATION OF THIRD:	1
RICOCHET (UNFAIR HIT), PERFORATION 3/4 BOARD:	1

STABILITY TESTS

YAW-CARD FIRING

FIRING RECORD NO. S-46201

DEVELOPMENT AND PROOF SERVICES
ABERDEEN PROVING GROUND, MARYLAND
FIRING RECORD

OBJECT OF TEST: To Determine the Stability Factor of a Special Caliber .22 Bullet.

DATES OF TEST: 7 - 10 June 1955
FIRING RECORD NO: S-46201
SHEET 1 OF 3
AUTHORITY: TT ORD 1548
Dated: 7 Jan. 1955
WORK ORDER NO.: 961-601-00

DEVELOPMENT: ORDTS
PROJECT NO. TS1-2

No 1

MATERIEL

Caliber .22 Accuracy Rifle, 10 inches/turn.
Caliber .22 Accuracy Rifle, 8 inches/turn.
Yaw Inducer, 1/4 - inch.

Frankford Arsenal machine rest.

AMMUNITION

Cartridge, ball, caliber .22, Special, hand loaded in special cases with 51 grains, W. E. X 487.2 propellant.

FACILITIES

No special facilities were required.

ROUND-BY-ROUND DATA

Stability Firing

GUN: Rifle, Accuracy, Cal..22, No.4747051 (10 inches/turn)
Rifle, Accuracy, Cal..22, No.1468719 (8 inches/turn)
AMMUNITION: Special, Cal. .22, Ball, APG 68-grain BT Bullet

FIRING (17 rounds with 10-inch barrel and 25 rounds with 8-inch barrel) was conducted on 24 May, 25 May and 6 June, to determine the approximate period and to obtain satisfactory degree of yaw, and yaw-card distribution.

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FIRING RECORD NO. S-4201
SHEET 2 OF 3

8-Inch Barrel

TIME	ROUND NO.	APPROXIMATE YAW, degrees	TEMPERATURE Degrees Dry	TEMPERATURE Degrees Wet	REMARKS
		Dense Distribution			7 June 1955
1305	1	10	78.0	69.5	
1340	2	10	80.5	71.5	
1405	3	10	80.0	73.0	
1445	4	10	78.0	72.0	
1500	5	10	78.0	74.0	
		Sparse Distribution			8 June 1955
		(Yaw cards were removed at stations: 4, 5, 6, 9, 10, 11, 12, 19, 20, 21, 24, 25, 26 and 27)			
0920	6	10	61.0	59.2	
0930	7	10	61.0	58.0	
0943	8	10	61.0	58.0	
1000	9	10	61.0	58.0	
1010	10	10	61.0	58.0	

10-inch Barrel — 9 June 1955

		Sparse Distribution			
1407	1	10	58.0	57.0	Yaw-inducer: 1/4-inch, for all rounds
1420	2	10	58.5	56.0	
1435	3	10	58.5	56.0	
		Dense Distribution			
1514	4	10	58.5	56.0	
1525	5	10	59.5	56.0	
1535	6	10	59.0	56.0	

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FIRING RECORD NO: S-4201
SHEET 3 OF 3

INSTRUMENTAL VELOCITY
AT 52 Feet — 10 June 1955

TIME	ROUND NO.	VELOCITY fps
1020	1	3496
	2	3468
	3	3417
	4	3460
1035	5	3492
Average:		3459

SUMMARY

The stability factor was determined, generally, in accordance with the method outlined in Ballistic Research Laboratories Report No. BRL X-113, and stability formulas from BRL Report No. 620. The determination was made from firing data for two different barrels, with 8-inch and 10-inch rifling, respectively.

From data with the 8-inch barrel, the stability factor was found to be 1.82, under standard meteorological conditions at muzzle, corresponding to a moment coefficient, K_M, of 0.923.

From data with the 10-inch barrel, the corresponding results were 1.14 for stability factor and 0.943 for moment coefficient. The weighted-mean value for K_M, from the 10 rounds with the 8-inch barrel and the 6 rounds with the 10-inch barrel is 0.931. Using this value of K_M, the stability factor was found to be as follows:

BARREL RIFLING, Inches/Turn	STABILITY FACTOR: STANDARD METEORO-LOGICAL CONDITIONS	STABILITY FACTOR: * At 29.53-in. H PRESSURE, and -65°F. Temp.
8	1.81	1.31
9	1.42	1.03
10	1.16	.84

* At a relative atmospheric density of 1.38.

APPROVED:

G. A. GUSTAFSON
Chief, Infantry and Aircraft Weapons Div.

for E. KITKOWSKI
Chief, Small Arms Br.

for J. A. MAHONEY
Ordnance Engineer

INCLOSURES: Yaw-card distribution
Stability Data and Results
Physical Test Laboratory Report

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TAG-CARD DISTRIBUTION

(Single cards at each station)

5-Inch Barrel

STATION No.		DISTANCE, Ft.	
DENSE	SPARSE	DENSE	SPARSE
1	1	8	8
2	2	10	10
3	3	12	12
4		14	
5		16	
6		18	
7	7	20	20
8	8	22	22
9		24	
10		26	
11		28	
12		30	
13	13	32	32
14	14	34	34
15	15	36	36
16	16	66	66
17	17	68	68
18	18	70	70
19		72	
20		74	
21		76	
22	22	78	78
23	23	80	80
24		82	
25		84	
26		86	
27		88	
28	28	90	90
29	29	92	92
30	30	94	94
31	31	96	96
32	32	200	200
33	33	202	202
34	34	204	204
35	35	206	206

YAW-CARD DISTRIBUTION

(Single cards at each station)

16-Inch Barrel

STATION NO.		DISTANCE, Ft.		STATION NO.		DISTANCE, Ft.	
DENSE	SPARSE	DENSE	SPARSE	DENSE	SPARSE	DENSE	SPARSE
1	1	10	10				
2		15		20	20		200
3	2	20	20		21		210
4		25			22		220
5	3	30	30		23		230
6		35			24		240
7	4	40	40		25		250
8		45			26		260
9	5	50	50		27		270
10		55			28		280
11	6	60	60				
12		65					
13	7	70	70				
14		75					
15	8	80	80				
16		85					
17	9	90	90				
18		95					
19	10	100	100				
20	11	110	110				
21	12	120	120				
22	13	130	130				
23	14	140	140				
24	15	150	150				
25	16	160	160				
26	17	170	170				
27	18	180	180				
28	19	190	190				

STABILITY DATA A

Caliber .22

Round No.	Density Ratio	Muzzle Tp Min. Yaw, Ft. First	Muzzle Tp Min. Yaw, Ft. Last	No. Of Age Periods	Age Period, Ft.	Correction Factor, σ^*
				8-Inch Barrel		
1	.9747	90	98.0	9	9.81	1.31
2	.9681	90	96.0	9	9.67	1.41
3	.9681	90	98.0	9	9.89	1.46
4	.9907	90	96.0	9	9.67	1.40
5	.9921	90	98.0	9	9.89	1.38
6	1.003	90	95.0	9	9.60	.611
7	1.008	10.0	94.5	9	9.40	.611
8	1.003	9.2	93.0	9	9.30	.733
9	1.003	90	93.0	9	9.30	.734
10	1.003	90	93.5	9	9.40	.742

Rounds 1-5 were fired thro the dense distri
rounds 6-10, through the sparse
the yaw-screen constant, $\sigma = 1.859$

				10-Inch Barrel		
1	1.000	20.0	280.0	12	21.67	1.16
2	1.007	20.0	280.0	12	21.67	1.11
3	1.007	20.0	150.0	6	21.67	1.65
4	1.007	26.0	94.0	3	22.70	1.86
5	1.002	22.0	190.0	7	23.00	1.50
6	1.002	27.0	190.0	7	23.30	1.41

Rounds 1-3 were fired through the sparse distribu
rounds 4-6, through the dense
The yaw screen constant, $\sigma = 1.91$
* $\sigma = \Sigma(\delta/\kappa)^2/n$, δ is the yaw, κ is the maximum

[illegible] DIVISION
[illegible] TEST LABORATORY [illegible]

ORDNANCE-0-5-15

TEST OF:

Five (5) Cal. .22 Bullets, Long Rifle, Special Before Firing.

OBJECT OF TEST:

To obtain the weight, center of gravity, moment of inertia and physical dimensions of the above bullets.

TEST PROCEDURE:

1. Instrumentation:
Analytical balance; center of gravity trough, torsion pendulum; stop watch, super-micrometer and contour projector.

Report No. 55-L-80

Sheet 1 of 1

Dates of Test February - March 1955

Report Complete 27 April 1955

Conducted for A.& A. Division

Small Arms Br. -Mr.J.A.Mahoney

Project No. TS1-2

Work Order No. 964-004-00

References C.P.H. 40-31

2. Procedure:

a. Moment of inertia was determined by timing the rotating of each bullet on a torsion pendulum.

b. Physical dimensions were obtained with the super micrometer.

c. Yaw versus major axis relationship was measured from 0° through 20° at 1° intervals on a contour projector.

d. Center of gravity was determined by the beam and scale method, using analytical balances, as outlined in C.P.H. 40-31 par. 10.

RESULTS:

See Appendix I for data.

1 Incl
Appendix I

Approved: J. W. McKinley,
Chief,
Physical Test Laboratory.

Signed: H. M. Jamison,
Measurements
Section.

(UNCLASSIFIED)

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CAL. .22 BULLET, LONG RIFLE, SPECIAL

Bullet No.	Body Dia. (inches)	Total Length (inches)	Total Wt. (GM)	Center of Gravity (inches from base)	Moment of Inertia GM in.² Axial	Transverse
1	.2242	.9448	4.4459	.393	.023254	.213383
2	.2242	.9452	4.4388	.393	.022208	.212967
3	.2242	.9464	4.4424	.400	.022832	.214127
4	.2242	.9478	4.4403	.398	.022724	.215208
5	.2242	.9538	4.4428	.401	.022821	.213838

MAJOR AXIS VERSUS DEGREES YAW

Degrees Yaw	Major Axis	Degrees Yaw	Major Axis
0°	.2242"	11°	.2966"
1	.2271	12	.3090
2	.2318	13	.3183
3	.2368	14	.3319
4	.2426	15	.3451
5	.2480	16	.3597
6	.2541	17	.3709
7	.2601	18	.3868
8	.2674	19	.3982
9	.2754	20	.4146
10	.2861		

Appendix I

CAL. .22 BULLET, LONG RIFLE, SPECIAL
Method of Computing Moments of Inertia - Transverse

$I_H = Kt^2_L - I_L$

$I_H = Kt^2_S - I_S$

$I_H = (104.63571)K - .27409381$
$I_H = (92.88141)K - .24193250$
$11.75430K = .03216131$
$K = .0027361314$

$I_H = Kt^2_L - I_L$

$I_H = (.0027361314)\ (104.63571) - .27409381$
$I_H = .28629705 - .27409381$
$I_H = .01220324$ gm. in.^{2}

$I_H = Kt^2_S - I_S$

$I_H = (.0027361314)\ (92.88141) - .24193250$
$I_H = .25413574 - .24193250$
$I_H = .01220324$ gm. in.^{2}

$I_p = Kt^2_p - I_H$

$I_p = (.0027361314)\ (82.4464) - .01220324$
$I_p = .22558418 - .01220324$
$I_p = .21338094$ gm. in.^{2}

Key:

I = Moment of Inertia
K = Constant
t = Time of swing
L = Large test mass
S = Small test mass
H = Holder
p = Projectile

Appendix I

CAL. 22 BULLET, LONG RIFLE, SPECIAL
Method of Computing Moments of Inertia - Axial

$I_H = Kt^2_L - I_L$

$I_H = Kt^2_S - I_S$

$I_H = (39.018762)K - .0554445$
$I_H = (25.796241)K - .0264191$
$13.222521K = .0290254$
$K = .0021951487$

$I_H = Kt^2_L - I_L$

$I_H = (.0021951487)\ (39.018762) - .0554445$
$I_H = .0856520 - .0554445$
$I_H = .0302075$ gm. in.^{2}

$I_H = Kt^2_S - I_S$

$I_H = (.0021951487)\ (25.796241) - .0264191$
$I_H = .0566266 - .0264191$
$I_H = .0302075$ gm. in.^{2}

$I_p = Kt^2_p - I_H$

$I_p = (.0021951487)\ (24.354225) - .0302075$
$I_p = .0534611 - .0302075$
$I_p = .023254$ gm. in.^{2}

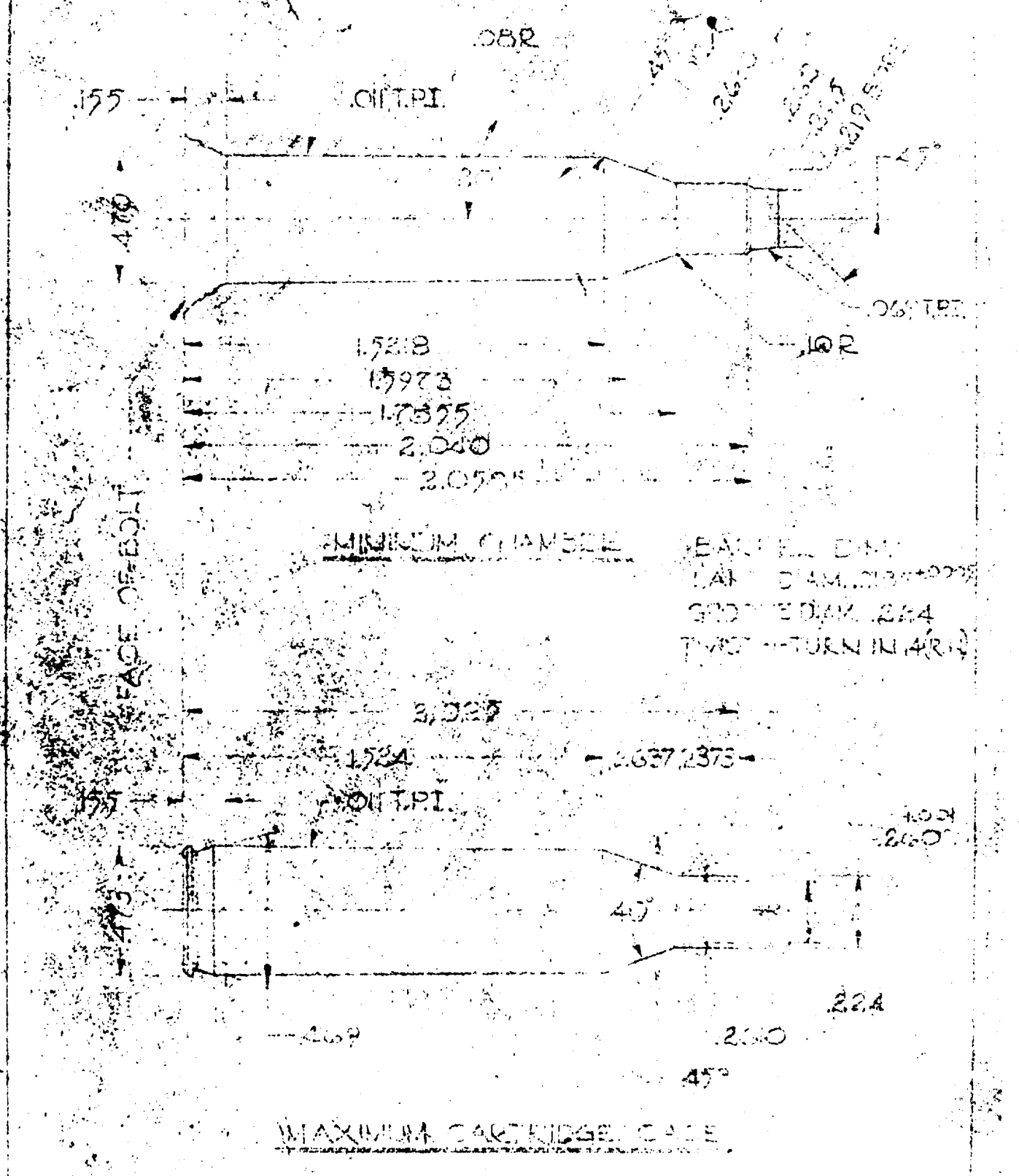
Key:

I = Moment of Inertia
K = Constant
t = time of swing
L = Large test mass
S = Small test mass
H = Holder
P = Projectile

Appendix I

APPENDIX C

MLRR NO. _____



CHAMBER FOR RIFLED CARTRIDGE CASE (R.H.)

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